NOTICE

All drawings located at the end of the document.

RF/RMRS-97-115.UN

Progress Report #2 to the Source Evaluation and Preliminary Mitigation Plan for Walnut Creek

November, 1997

U.S. Department of Energy

Rocky Flats Environmental Technology Site

Golden, Colorado

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1. INTRODUCTION

This Source Evaluation Progress Report is provided in accordance with the Final Rocky Flats Cleanup Agreement (RFCA) (Attachment 5, §2.4(B)) under "Action Determinations". The RFCA requires reporting of "exceedances in Segment 5" and when "standards are exceeded at a POC" and that a "source evaluation and mitigating action will be required". Specifically, this source evaluation addresses the August 15, 1997 Rocky Flats Environmental Technology Site (Site) report of elevated 30-day moving averages for plutonium (Pu) and americium (Am) water-quality results in Walnut Creek. These elevated values were measured at the Point of Compliance (POC) monitoring location at Walnut Creek and Indiana Street (referred to as GS03) for the period June 12, 1997 through July 2,1997. Elevated values were also measured at the Point of Evaluation (POE) monitoring location above Pond B-1 (referred to as GS10) for the periods April 13, 1997 through April 24,1997, May 25, 1997 through June 20, 1997, August 2, 1997 through September 3, 1997, and September 22 to present.[1] Finally, elevated values were observed at the POE monitoring location above Pond A-1 (referred to as SW093) for the period August 2, 1997 through August 3,1997. This Source Evaluation Progress Report #2 is the second in a series the Site has committed to completing as outlined in Source Evaluation and Preliminary Proposed Mitigating Actions for Walnut Creek Water-Quality Results, September 1997 (Revision 2; RF/RMRS-97-081.UN). This Plan was delivered to the Colorado Department of Public Health and the Environment (CDPHE), the Environmental Protection Agency (EPA), the City of Broomfield and the City of Westminster, on September 15, 1997.

The Site considers the recent elevated water-quality measurements at Site POCs and POEs serious in nature. Elevated values such as these have not previously been measured at GS03. The Site maintains open communication with regulators, cities, and stakeholders to relay the progress of the investigation. The Site has initiated a surface-water source investigation incorporating a multitude of onsite and offsite expertise, as well as state-of-the-art research methods and technologies. The Site has initiated extensive data evaluations, additional field investigations (soil, sediment, and water analyses), and assessments of Site activities and monitoring programs. Activities and administrative changes have been implemented as quickly as practicable to determine the cause of these elevated measurements and continue to protect water quality. The Walnut Creek source location activities undertaken by the Site thus far, indicate that the GS03 exceedance is most likely the result of legacy contamination. The source evaluation has uncovered no information that indicates that recent Site activities are responsible.

In order to allow sufficient time for effective source evaluation, while simultaneously providing the more frequent dissemination of information and results as they become available, a series of three Source Evaluation Progress Reports, and a Final Source Evaluation and Mitigating Action Plan will be completed. Progress Reports will be produced at intervals during the source evaluation process as specific actions are

[1] The latest analytical result returned from the labs covers the period up to 9/22/97. For 9/22/97, the 30-day average was still above 0.15 pCi/L Pu.

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completed. During the production of each deliverable, additional information will be collected which will be included in subsequent reports as available. Data collection schedules are often weather dependent (collection of runoff samples) and subject to laboratory analysis turnaround times. The scope of additional information collection is flexible and should be expected to change based on the knowledge gained during the source evaluation activities. The schedule is given in Table 1-1.

Table 1-1. Schedule of Deliverables.

Deliverable	Completion Date
Source Evaluation Progress Report #1	September 30, 1997; Complete
Source Evaluation Progress Report #2	November 17, 1997
Source Evaluation Progress Report #3	December 31, 1997
Final Source Evaluation Report and Mitigating Action Plan	April 15, 1998

Source evaluations require analysis of constituent fate, transport, and loading, as well as statistical analysis and the establishment of water-quality correlations which may indicate the location of a contaminant source. This Progress Report #2 describes the progress of source evaluation actions for Walnut Creek gaging stations GS03, GS10, and SW093 and covers data received by October 31, 1997. Source evaluations are required to determine the location, extent, and significance of areas which may have an impact on surface-water quality. This Source Evaluation Progress Report #2 includes the ongoing assessment of monitoring data for GS03, an assessment of existing data for GS10, and a preliminary evaluation for SW093. The following is included in this Progress Report #2 for Walnut Creek:

- Hypotheses for source location(s) with supporting and non-supporting information, including preliminary results on source location;
- Results and analysis of ongoing RFCA monitoring;
- Updates to the ongoing GS03 evaluation;
- An assessment and incorporation of available new data for GS03;
- A summary of walk-down activities and observations for GS10;
- An assessment of existing monitoring data for GS10;
- A detailed description of new sediment/soil sampling locations for GS10 and SW093;
- A detailed description of proposed new Source Location monitoring stations[2] for GS10 and SW093;

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[2] Source Location monitoring stations are automated gaging stations installed as part of a source evaluation under RFCA. These locations are installed according to the SW IMP Source Location decision rule and current Site

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- A summary of current Actinide Migration Study findings with cross-links to source evaluations; and

- A summary of the status for sampling and operational modifications (see Section 9.2).

2. BACKGROUND

2.1. SITE HYDROLOGY

Walnut Creek, the subject of this investigation and one of several Site drainages, flows east past the Site's boundary at Indiana Street. Surface-water monitoring station GS03 is located on Walnut Creek approximately 100 yards west of Indiana Street. Downstream of Indiana Street, flows are diverted around Great Western Reservoir via the Broomfield Diversion Ditch, and back to Walnut Creek. Walnut Creek then flows into Big Dry Creek, and on to the South Platte River.

Walnut Creek Tributaries

Upstream from station GS03, Walnut Creek receives flow from the following four tributaries (listed in order from north to south and shown in Figure 2-1):

- McKay ByPass Canal (Coal Creek water conveyance canal);

- No Name Gulch (buffer zone drainage basin east of the Landfill Pond);

- North Walnut Creek (northern Industrial Area (IA) drainage basin); and

- South Walnut Creek (central IA drainage basin).

No Name Gulch and the McKay Bypass Canal flow only during the spring or following large storm events, receive runoff from non-IA drainage basins, and are not controlled by detention ponds. The McKay Bypass is also used by Broomfield to transfer water from Coal Creek to Great Western Reservoir. North and South Walnut Creek, in contrast, both have nearly continuous baseflow, receive runoff from the IA, and are controlled by a system of detention ponds. A discussion follows describing how water runs off the IA, into North and South Walnut Creeks, through the detention pond network, and, ultimately, into Walnut Creek where it flows past station GS03.

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automated surface-water monitoring practices. Operation of these gages is tailored to meet the requirements of each source evaluation.

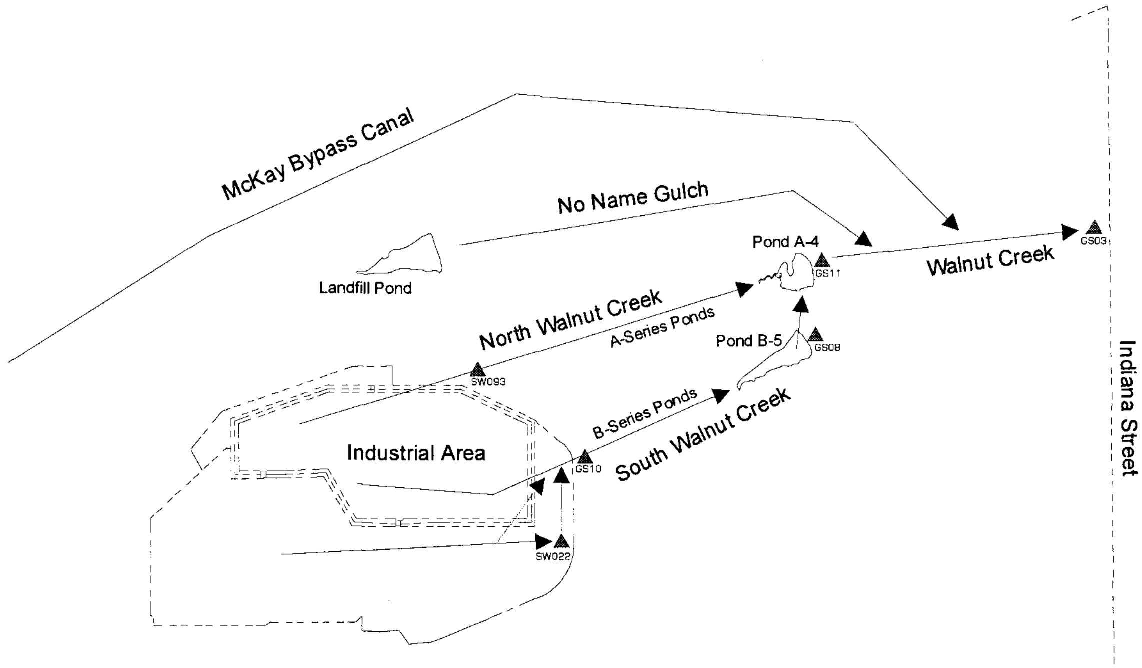

Figure 2-1. Hydrologic Connectivity of Site Drainage and Water Management Features.

North and South Walnut Creek Flow Controls

All IA surface-water runoff that flows into North or South Walnut Creek is collected in a system of Site detention ponds. The ponds serve three main purposes for surface-water management: (1) storm water detention and settling of sediments, (2) water storage for sampling and, if necessary, treatment prior to release, and (3) emergency spill control in those instances where a spill cannot be adequately managed without use of the ponds.

South Walnut Creek water is routed through the B-Series ponds[3]. Steps in the water collection and transfer process are briefly outlined as follows:

- Runoff from the south-central IA flows through the Central Avenue Ditch to SW022, and then to GS10 (during high runoff periods, some water in the Central Avenue Ditch overflows to a large corrugated metal pipe and flows directly to GS10; shown by dotted line in Figure 2-1);
- Runoff from the central IA flows directly to GS10;

[3] The Pond B-5 outlet works are scheduled to be upgraded in the beginning of FY98. WWTP effluent, which normally flows to B-3 and then B-5, will be pump transferred to A-3 to keep B-5 de-watered. Stormwater flows to B-5 will be detained in B-5. This water will be periodically pump transferred to A-4 to keep the construction site dry. Once the B-5 outlet works are completed in February 1998, water will be direct batch discharged to Walnut Creek.

- Runoff from GS10 then flows downstream through conveyance structures to Pond B-4 and on to Pond B-5 where it is held; and

- Water held in Pond B-5 is pumped periodically (≈ 9 times per year) in batches over to Pond A-4.

North Walnut Creek water is routed through the A-Series ponds. Steps in the water collection and transfer process are summarized as follows:

- Runoff from the northern IA flows directly to SW093;

- Runoff from SW093 flows downstream into Pond A-3;

- Water is held in Pond A-3, then periodically (≈ 9 times per year) released in batches into Pond A-4; and

- After Pond A-4 is filled to roughly 50% of capacity, flows into Pond A-4 (from Ponds A-3 and B-5) are discontinued, thereby isolating the A-4 water from the rest of the pond network. A sample of the A-4 water is collected by CDPHE, and if sample results indicate water quality standards are met, the "batch" of water is discharged through the outlet works of Pond A-4. Samples are collected of the Pond A-4 discharge water, at station GS11, and the water flows on to Walnut Creek and station GS03. These batch releases from Pond A-4 occur from 6 to 12 times per year, depending on the amount of precipitation received at the Site, and involve approximately 100 to 200 million gallons of water annually.

As indicated above, all of the IA runoff that flows into North and South Walnut Creeks is ultimately routed through Pond A-4, detained, and sampled prior to being released to flow to Walnut Creek. There is no source of runoff from the IA that can enter Walnut Creek without first passing through the pond system and then be discharged from Pond A-4. Downstream from Pond A-4, the only sources of surface-water entering Walnut Creek upstream of GS03 are No Name Gulch, the McKay Bypass Canal, or overland runoff directly into Walnut Creek.

2.2. GS03 MONITORING RESULTS

As specified in the draft Surface Water Integrated Monitoring Plan (SW IMP), the Site's Water Management & Treatment (WM&T) group evaluates 30-day moving averages[4] for selected radionuclides at RFCA POEs and POCs. Continuous flow-paced sampling is conducted at all RFCA POEs and POCs

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[4] The 30-day average for a particular day is calculated as a volume-weighted average of a 'window' of time containing the previous 30-days which had flow. Each day has its own discharge volume (measured at the location with a flow meter) and activity (from the sample carboy in place that day). Therefore, there are 365 30-day moving averages for a location which flows all year. At locations which monitor pond discharges or have intermittent flows, 30-day averages are reported as averages of the previous 30 days of greater than zero flow. For days where no activity is available, either due to failed lab analysis or NSQ for analysis, no 30-day average is reported.

through the use of automated flow-measurement and sampling equipment[5]. This section presents recent evaluations of water-quality measurements at POC surface-water monitoring location GS03 (see Figure 2-3) show values above the POC Standard value of 0.15 pCi/L Pu and Am. GS03 is located on Walnut Creek at Indiana Street. Results for 30-day moving averages using available data at GS03 are summarized below in Table 2-1 and are also plotted in Figure 2-2. The mean daily flow rate and available individual sample results are plotted in Figure 2-4.

Table 2-1. Water-Quality Information from GS03 for the Period: October 1, 1996 -August 31, 1997.

Location	Parameter	Date(s) 30-Day Average Above 0.15 pCi/L	Date(s) of Maximum 30-Day Average	Maximum 30-Day Average (pCi/L)	Volume Weighted Average for Water Year 1997 to Date[6] (pCi/L)
GS03	Pu-239,240	6/12/97 - 7/2/97	6/13/97 - 6/24/97	0.465	0.036
GS03	Am-241	6/13/97 - 6/24/97	6/13/97 - 6/24/97	0.256	0.017

For reference, the 30-day average at GS03 was between 0.05 pCi/L and 0.15 pCi/L for the following periods: April 16-26, 1997; June 10-11, 1997; July 3-5, 1997; and August 5-26, 1997.

The individual analytical results for the composite samples collected around the period of these elevated 30-day averages have been reviewed, and there is no reason to question their accuracy. Based on past analytical results for this location, these elevated values are considered unusual, with historical measurements being well below 0.05 pCi/L.[7] Samples collected after the period of elevated measurements showed normal Pu and Am activities. Individual composite sample results and details are shown in Table 2-2 for the periods of interest.

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[5] Through the use of a Data Quality Objectives (DQO) process, the SW IMP specifies the target number of composite samples ('carboys' receiving multiple grabs) to be collected at each monitoring location. The IMP further specifies that these carboys should be flow-paced. The flow pacing is based on the predicted stream discharge using historic record for each location. For example (for a specific location), if two carboys are targeted for a certain month, and the historic discharge volume is 100,000 gallons, then each carboy should represent 50,000 gallons. Grab samples of 200 ml are collected; smaller grabs push the repeatability limits of the auto-sampler. Since the carboys can hold 15l, and the minimum volume for analysis is ≈ 5l; the samplers are programmed to place 10l (50 grabs) in the carboy. So, for 50,000 gallons, the sampler is programmed for 1 grab per 1,000 gallons (50,000 gals/50 grabs). Targeting 50 grabs allows for periods of discharge greater than expected (up to 75 grabs) without having to collect additional carboys. Similarly, periods of discharge less that expected (25 grabs) may still yield enough sample for analysis.

[6] A water year (abbreviated as WY) is defined as the period October 1 through September 30.

[7] Historical values are available in the Site Annual Environmental Reports and the Quarterly Environmental Monitoring Reports. Detailed information is also presented in Section 3.1.

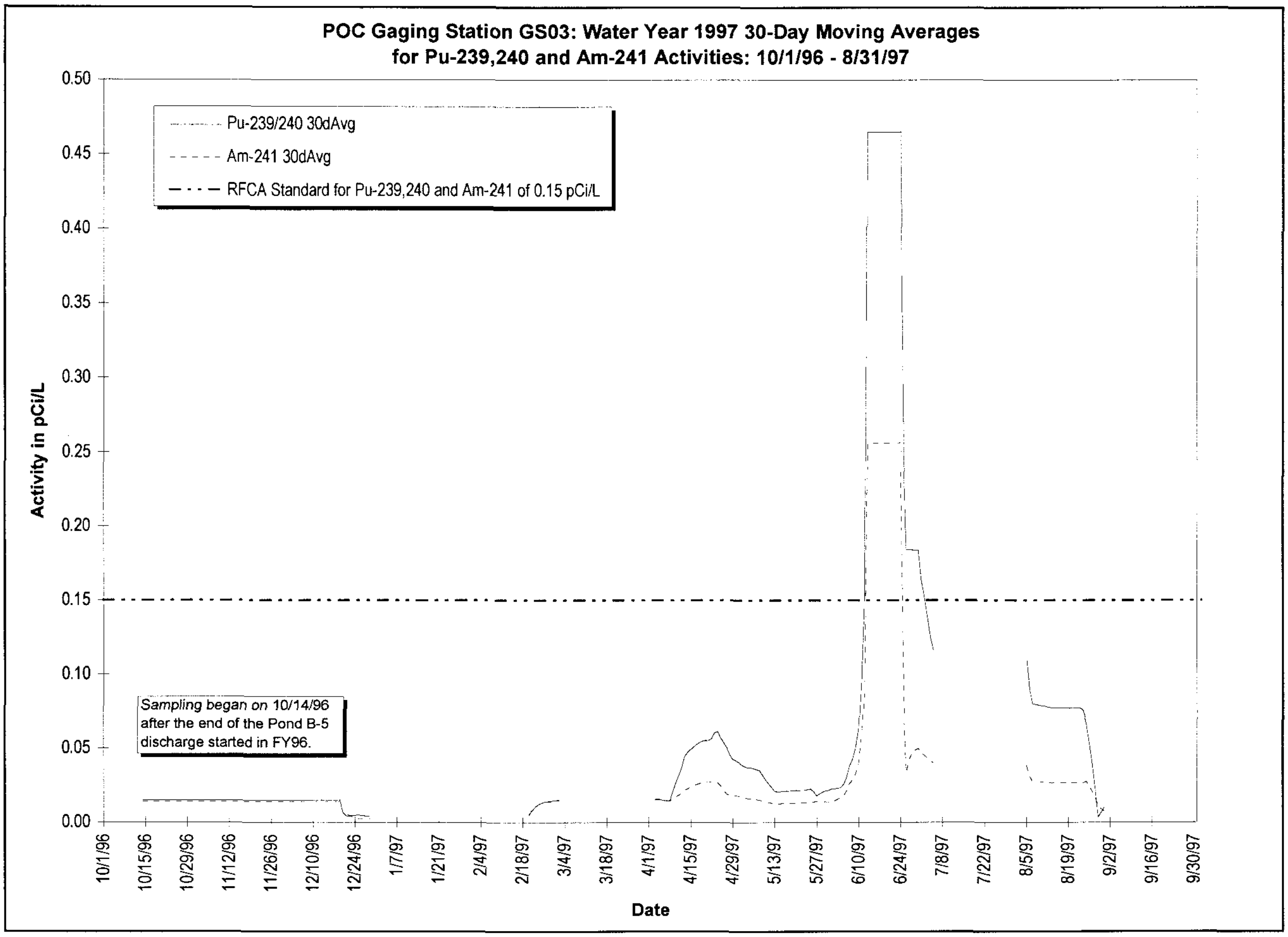

Figure 2-2. Gaging Station GS03 30-Day Averages: October 1, 1996 - August 31, 1997.

The composite sample at GS03 for the period May 15, 1997 - June 25, 1997 was collected during baseflow conditions between Pond A-4 (the terminal pond for North Walnut Creek) discharges. It should be noted that this is a low volume sample (NSQ[8]); radio-analytical protocol recommends a minimum sample volume of 4 liters to produce accurate radio-analytical results. The two composite samples at GS03 for the period June 25, 1997 - July 1, 1997 were collected as the first 2-of-3 composites during a Pond A-4 discharge (See Table 2-3 for Summary of Pond Discharges from April through September 1997). Analytical results for composite samples from POC gaging station GS11 (location shown on Figure 2-3), which monitors

[8] For situations where non-sufficient quantity (NSQ) is collected for analysis, either due to equipment failures or exceptionally low streamflows, the SW IMP specifies that the sample may be discarded. NSQ for GS03 occurs occasionally for baseflow periods. At GS03, the SW IMP targets 1 carboy for the periods of baseflow between Terminal pond discharges. The SW IMP further specifies that the carboy must represent only baseflow, and must be removed from the sampler at the beginning of a Terminal pond discharge. Therefore, if flows significantly less than predicted are measured at GS03, the flow-paced carboy may not receive sufficient volume for analysis before it must be removed from the sampler.

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controlled discharges from Pond A-4, show no elevated readings for Pu-239,240 or Am-241 for the discharges which occurred during the period of elevated measurements at GS03. Table 2-4 and Figure 2-5 summarize these results.

These results indicate that water discharged from the Site's Terminal Ponds is not the source of the elevated measurements at GS03. This information suggests that the source of the Pu and Am measured at GS03 is downstream of the Terminal Ponds or located in a tributary to Walnut Creek in the Terminal Pond-to-GS03 stream reach. This area has no known sources of significant contamination. For reference, Figure 2-1 shows the hydrologic routing for drainages and water management facilities which are related to GS03.

Table 2-2. Selected Composite Sample Analytical Results for GS03.

Composite Sample Period	Pu-239,240 (pCi/L)		Am-241 (pCi/L)		Composite Sample Volume (Liters)	Walnut Cr. Discharge Volume During Sample Period (Million Gallons)
	Result	Error	Result	Error		
4/8 - 4/13/97	0.220	0.045	0.059	0.064	1.2[a]	5.31
5/15 -6/25/97[b]	0.465	0.129	0.256	0.116	1.0	0.34
6/25 - 6/27/97	0.165[c]	0.052	0.018	0.021	8.0	2.83
6/27 - 7/1/97	0.184	0.046	0.056	0.036	8.6	5.37
7/1 - 7/6/97	0.000[d]	0.006	0.024	0.022	8.4	4.11
8/5 - 8/8/97[e]	0.002	0.011	0.002	0.023	17.4	5.42
8/8 - 8/29/97	0.028	0.000	0.008	0.008	6.8	0.35
8/29 - 9/1/97	0.023	0.004	0.004	0.007	8.8	5.69

[a] Low sample volume (1.2 liter) due to frozen sampler lines; this sample did not give a 30-day Pu average above 0.15 pCi/L.
[b] Low sample volume (1 liter) due to dry weather and associated low flows.
[c] This is an arithmetic average for values of the first analytical run (0.206 pCi/L) and a rerun (0.124 pCi/L); error is the arithmetic average error.
[d] Actual result was -0.004 pCi/L for this sample; result is set to zero for practical reporting and calculation purposes.
[e] During the period from 7/6/97 - 8/5/97, the sampler collected an insufficient quantity for analysis due to unanticipated low flow rates.

Table 2-3. Summary of Terminal Pond Discharges for April 3, 1997 - October 10, 1997.

Location	Discharge Dates	Volume Discharged (gal)
Pond A-4	4/3/97 - 4/13/97	13,609,000
Pond B-5	4/28/97 - 5/12/97	15,450,000
Pond A-4	5/1/97 - 5/14/97	25,616,000
Pond A-4	6/25/97 - 7/6/97	13,319,000
Pond A-4	8/5/97 - 8/7/97	4,250,000
Pond A-4	8/29/97 - 9/8/97	17,916,000
Pond B-5	9/24/97 - 10/10/97	12,006,000

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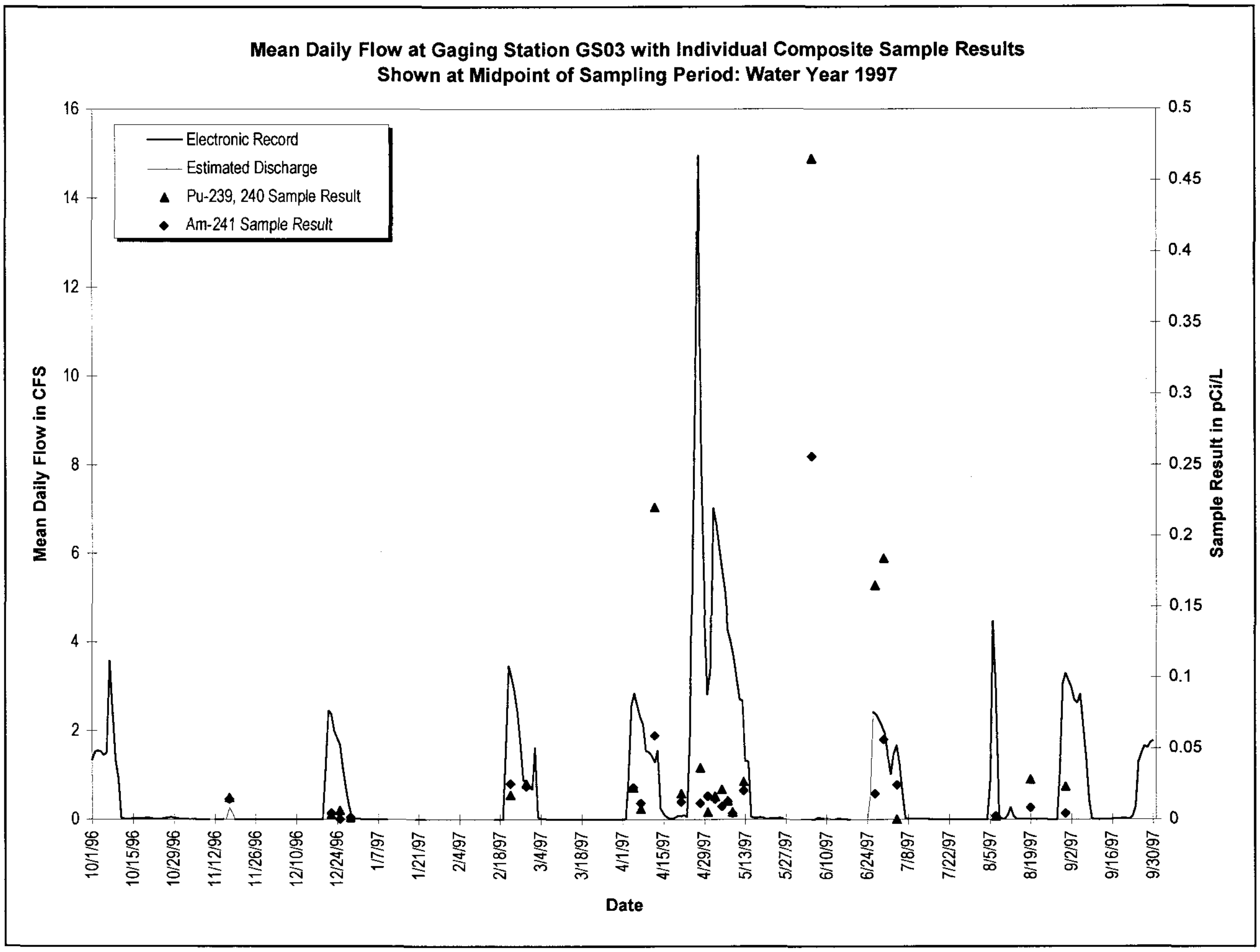


Intermittent peaks are from Terminal Pond A-4 and B-5 discharges; runoff peak (≈ 4/24 - 4/28) is from large snowmelt event. Sampling began on 10/14/96 after the completion of a B-5 discharge. Samples shown where data has been received form analytical labs (10/1/96 - 8/31/97).

Figure 2-4. Gaging Station GS03 Hydrograph and Sample Results.

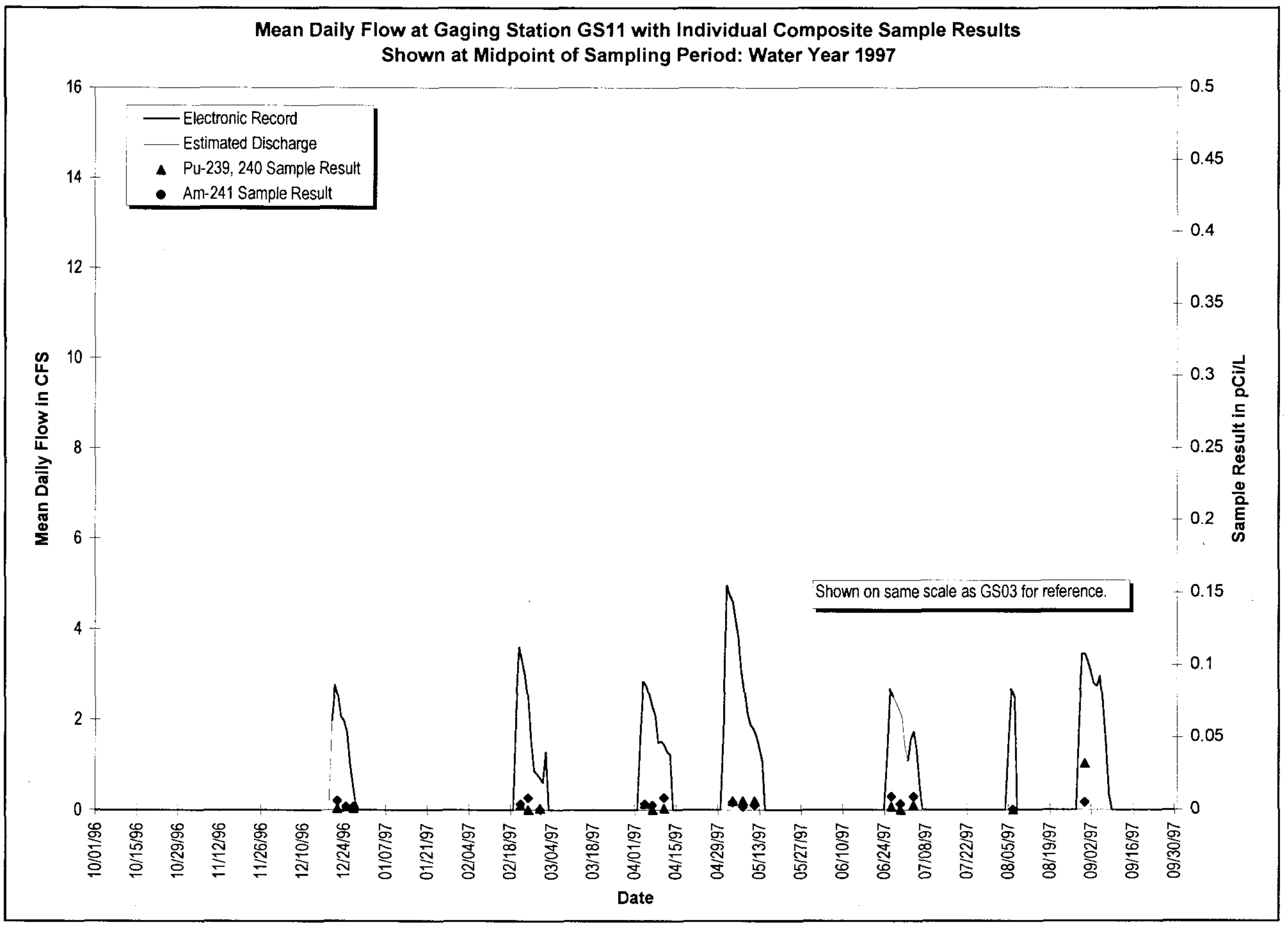
During the time period of elevated measurements at GS03, no off-normal conditions were noted in either decontamination and decommissioning (D&D), special nuclear material (SNM) stabilization, or environmental restoration (ER) activities that may have affected water quality, nor were there any closure activities occurring in the Walnut Creek drainage between Pond A-4 and Indiana Street. An initial walk-down of the Walnut Creek drainage between GS03 and Pond A-4 was conducted on August 15, 1997 and revealed no unusual conditions which might provide insight into elevated radionuclides in surface water for the May-July timeframe. Immediately downstream of station GS03 the water flowed offsite and was diverted around Great Western Reservoir, thus the downstream effect cannot be quantified. Pond A-4 discharges during this period showed normally low Pu and Am levels (as shown in Table 2-4).

Table 2-4. Composite Sample Analytical Results for GS11: April 8 - September 1, 1997.

Composite Sample Period	Pu-239,240 (pCi/L)		Am-241 (pCi/L)		Composite Sample Volume (Liters)	Pond A-4 Discharge Volume During Sample Period (Million Gallons)
	Result	Error	Result	Error		
4/8 - 4/13/97	0.001	0.005	0.008	0.012	8.2	4.98
5/1 - 5/6/97	0.006	0.004	0.005	0.007	17.4	14.61
5/6 - 5/8/97	0.006	0.005	0.002	0.006	6.8	3.85
5/8 - 5/14/97	0.006	0.004	0.003	0.005	10.6	7.16
6/25 - 6/27/97	0.002	0.005	0.009	0.011	9.4	3.42
6/27 - 7/1/97	0.000[a]	0.012	0.004	0.017	4	5.67
7/1 - 7/6/97	0.003	0.012	0.009	0.012	7.8	4.22
8/5 - 8/7/97	0.000[b]	0.008	0.000	0.013	13.8	4.25
8/29 - 9/1/97	0.032	0.003	0.005	0.006	10.6	6.62

[a] Actual result was -0.009 pCi/L for this sample; result is set to zero for practical reporting and calculation purposes.

[b] Actual result was -0.008 pCi/L for this sample; result is set to zero for practical reporting and calculation purposes.



Samples shown where data has been received form analytical labs (10/1/96 - 9/1/97).

Figure 2-5. Gaging Station GS11 Hydrograph and Sample Results.

2.3. GS10 MONITORING RESULTS

As specified in the draft SW IMP, the Site's WM&T group evaluates 30-day moving averages[4] for selected radionuclides at gaging station GS10. GS10 receives flow from the central IA and monitors flow to South Walnut Creek via the B-1 bypass pipeline to Pond B-4 which flows into Pond B-5. Recent evaluations of water-quality measurements at POE surface-water monitoring location GS10 (located on South Walnut Creek just above Pond B-1 as shown on Figure 2-3) show values above 0.15 pCi/L for Pu and Am. Results for 30-day moving averages using available data at GS10 are summarized below in Table 2-5 and are shown on Figure 2-6.

The analytical results for the composite samples collected around the period have been verified. A review of historical monitoring data shows that these results are not unusual. Storm-event[9] samples collected at GS10 from 1992 through 1996 (under pre-RFCA protocols) had an arithmetic average Pu-239,240 activity of 0.23 pCi/L with a maximum of 1.4 pCi/L. The apparent upward trend during WY97 is likely due to seasonally increasing flow rates which carry increased suspended material. The significant increase in activity during the first week of August 1997 occurred due to intense runoff events associated with the summer monsoon weather patterns.

Table 2-5. Water-Quality Information from GS10 for the Period: October 1, 1996 - September 22, 1997.

Location	Parameter	Date(s) 30-Day Average Above 0.15 pCi/L	Date(s) of Maximum 30-Day Average	Maximum 30-Day Average (pCi/L)	Volume Weighted Average for WY97 to Date (pCi/L)
GS10	Pu-239,240	4/13/97 - 4/24/97 5/25/97 - 6/20/97 8/2/97 - 9/3/97 9/22/97 - [b]	8/5/97	0.921	0.242
GS10	Am-241	5/25/97 - 6/14/97 8/4/97 - 9/22/97[b]	8/31/97	1.063	0.294

[a] Samples shown where data has been received from analytical labs (10/1/96 - 9/22/97).
[b] As of 9/22/97, the GS10 30-day average remains above 0.15 pCi/L.

For reference, the 30-day average at GS10 was between 0.05 pCi/L and 0.15 pCi/L for the following periods: October 26 - November 18, 1996; December 11-29, 1996; January 14 - April 12, 1997; April 25 - May 24, 1997; June 21 - August 1, 1997; and September 4-21, 1997.

[9] Storm-event samples are generally flow-paced composites consisting of 15 grabs taken during a direct runoff hydrograph. The grabs are targeted to be taken on the rising limb.

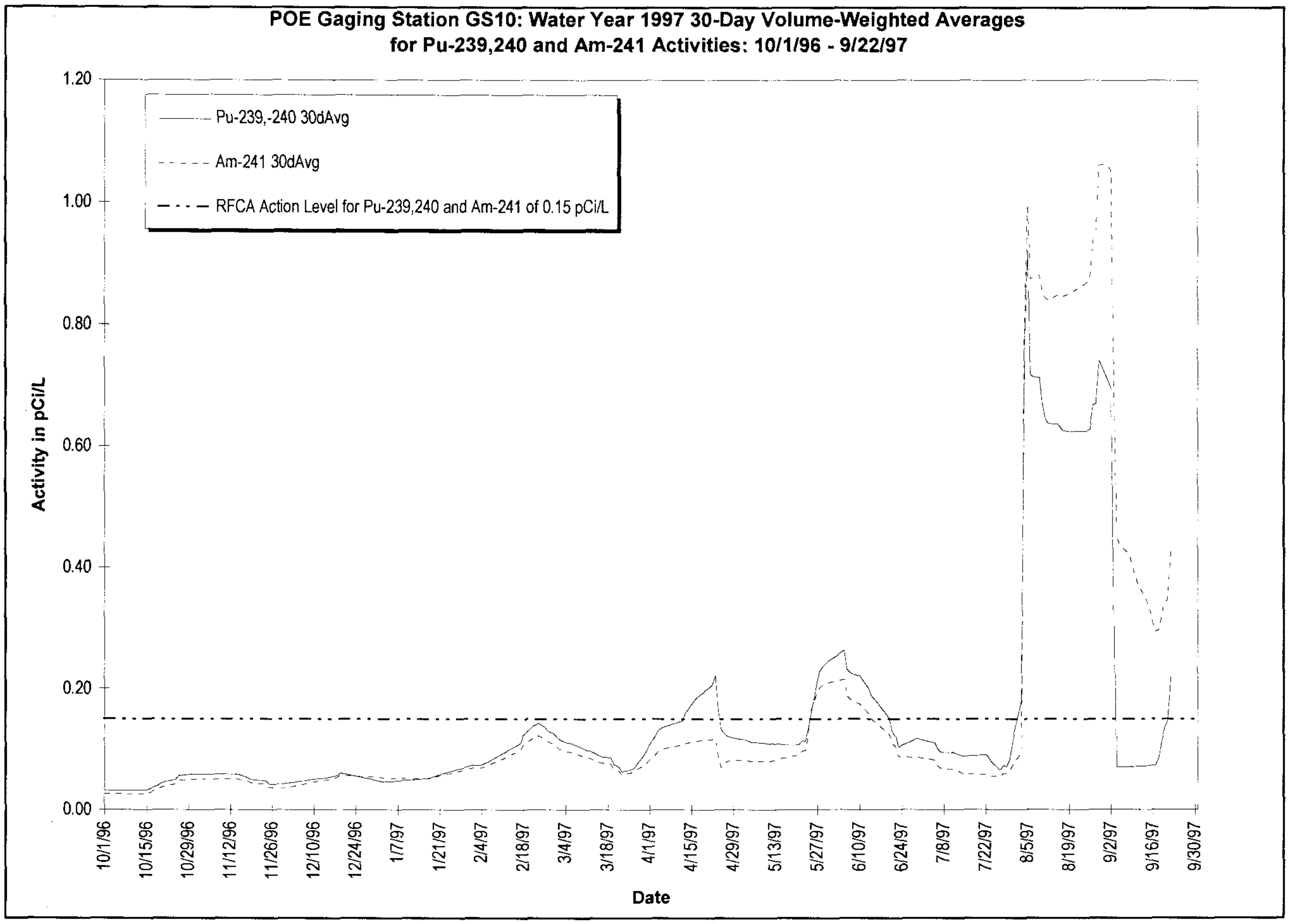


Figure 2-6. Gaging Station GS10 30-Day Averages: October 1, 1996 - September 22, 1997.

All water monitored at GS10 during this period subsequently flowed to Pond B-5 and was transferred to Pond A-4 for subsequent discharge or direct discharged from B-5 to Walnut Creek. Pre-discharge samples of the water in Ponds A-4 and B-5 indicated acceptable water quality for all discharges. Analytical results from composite samples collected at gaging station GS11 at the Pond A-4 outfall during each discharge were well below the RFCA standard (see Table 2-4). Results from GS08 for the September 24, 1997 - October 10, 1997 B-5 discharge have not been returned from the labs. This improvement in water-quality between pond influent and effluent indicates that the Site's water-management practices help mitigate contamination. Individual composite sample results and detail for GS10 are shown in Table 2-6 for the period of interest.

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Table 2-6. Composite Sample Analytical Results for GS10: March 28, 1997 - June 8, 1997.

Composite Sample Period	Pu-239,240 (pCi/L)		Am-241 (pCi/L)		Composite Sample Volume (Liters)	S. Walnut Cr. Discharge Volume During Sample Period (Million Gallons)
	Result	Error	Result	Error		
3/28 - 4/2/97	0.300	0.026	0.140	0.015	6.0	0.29
4/2 - 4/11/97	0.150	0.017	0.110	0.021	8.8	1.37
4/11 - 4/24/97	0.410	0.041	0.140	0.019	12.2	2.45
4/24 - 4/25/97	0.086	0.014	0.045	0.009	12.8	1.60
4/25 - 4/26/97	0.070	0.012	0.033	0.009	11.0	2.41
4/26 - 5/12/97	0.086	0.014	0.120	0.017	4.0	2.70
5/12 - 5/25/97	0.380	0.049	0.300	0.044	7.4	1.19
5/25 - 6/8/97	0.134	0.043	0.106	0.053	9.6	1.66
6/8 - 6/12/97	0.056	0.027	0.052	0.032	6.0	0.32
6/12 - 6/16/97	0.088	0.030	0.077	0.036	8.8	0.46
6/16 - 6/23/97	0.005	0.010	0.048	0.033	7.2	0.36
6/23 - 6/30/97	0.274	0.073	0.100	0.051	6.6	0.36
6/30 - 7/8/97	0.056	0.036	0.061	0.048	9.4	0.35
7/8 - 7/16/97	0.028	0.020	0.032	0.023	11.8	0.42
7/16 - 7/23/97	0.026	0.025	0.043	0.026	11.2	0.41
7/23 - 7/31/97	0.107	0.047	0.075	0.054	15.2	1.97
7/31 - 8/4/97	1.460	0.197	0.497	0.173	11.2	1.19
8/4 - 8/6/97	1.910	0.256	2.210	0.382	15.4	2.24
8/6 - 9/1/97	0.070	0.002	0.468	0.006	15.0	3.42
9/1 - 9/18/97	0.077	0.034	0.130	0.080	10.2	0.76
9/18 - 9/23/97	0.427	0.072	0.687	0.151	15.0	1.72

2.4. SW093 MONITORING RESULTS

As specified in the draft SW IMP, the Site's WM&T group evaluates 30-day moving averages[4] for selected radionuclides at gaging station SW093. SW093 receives flow from the northern and central IA and monitors flow to North Walnut Creek via the A-1 bypass pipeline to Pond A-3 which is batch discharged into Pond A-4. Recent evaluations of water-quality measurements at POE surface-water monitoring location SW093 (located on North Walnut Creek above Pond A-1 as shown on Figure 2-3) show values above 0.15 pCi/L for Pu. Results for 30-day moving averages using available data at SW093 are summarized below in Table 2-7 and are shown on Figure 2-7.

A review of historical monitoring data shows that these results are not unusual. Storm-event samples collected at SW093 from WY92 through WY96 (under pre-RFCA protocols) had an arithmetic average Pu-239,240 activity of 0.734 pCi/L with a maximum of 5.3 pCi/L. The apparent upward trend during WY97 is likely due to seasonally increasing flow rates which carry increased suspended material. The significant increase in activity during the first week of August 1997 occurred due to intense runoff events associated

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with the summer monsoon weather patterns. To the best of the Site's knowledge, no off-normal conditions were experienced at any D&D, SNM stabilization, or ER activities during this time period that could have affected water quality.

Table 2-7. Water-Quality Information from SW093 for the Period: October 1, 1996 - September 22, 1997.

Location	Parameter	Date(s) 30-Day Average Above 0.15 pCi/L	Date(s) of Maximum 30-Day Average	Maximum 30-Day Average (pCi/L)	Volume Weighted Average for WY97 to Date (pCi/L)
SW093	Pu-239,240	8/2 - 8/3/97	8/3/97	0.181	0.040

[a] Samples shown where data has been received from analytical labs (10/1/96 - 9/22/97).

For reference, the 30-day average at SW093 was between 0.05 pCi/L and 0.15 pCi/L for the following periods: October 1, 1996 - January 9, 1997; April 25, 1997; July 26 - August 1, 1997; and August 4-31, 1997.

All water monitored at SW093 during this period subsequently flowed to Pond A-3 and was batch discharged to Pond A-4 for subsequent batch discharge to Walnut Creek. Pre-discharge samples of the water in Pond A-4 indicated acceptable water quality for all discharges. Analytical results from composite samples collected at gaging station GS11 at the Pond A-4 outfall during each discharge were well below the RFCA standard (see Table 2-4). This improvement in water-quality between pond influent and effluent indicates that the Site's water-management practices help mitigate contamination. Individual composite sample results and detail for SW093 are shown in Table 2-8 for the period of interest.

Table 2-8. Composite Sample Analytical Results for SW093: July 21 - September 22, 1997.

Composite Sample Period	Pu-239,240 (pCi/L)		Am-241 (pCi/L)		Composite Sample Volume (Liters)	S. Walnut Cr. Discharge Volume During Sample Period (Million Gallons)
	Result	Error	Result	Error		
7/21 - 7/29/97	0.208	0.063	0.037	0.074	10.2	0.46
7/29 - 7/30/97	0.224	0.063	0.247	0.087	13.4	0.78
7/30 - 8/1/97	0.037	0.025	0.026	0.034	8.0	0.39
8/1 - 8/4/97	1.330	0.213	0.628	0.166	12.8	1.18
8/4 - 8/6/97	0.085	0.035	0.044	0.037	15.0	2.70
8/6 - 8/12/97	0.020	0.200	0.036	0.201	13.0	2.81
8/12 - 9/1/97	0.002	0.005	0.016	0.005	8.4	1.89
9/1 - 9/18/97	0.002	0.009	0.000	0.014	12.4	0.79
9/18 - 9/23/97	0.018	0.016	0.033	0.028	15.0	1.66

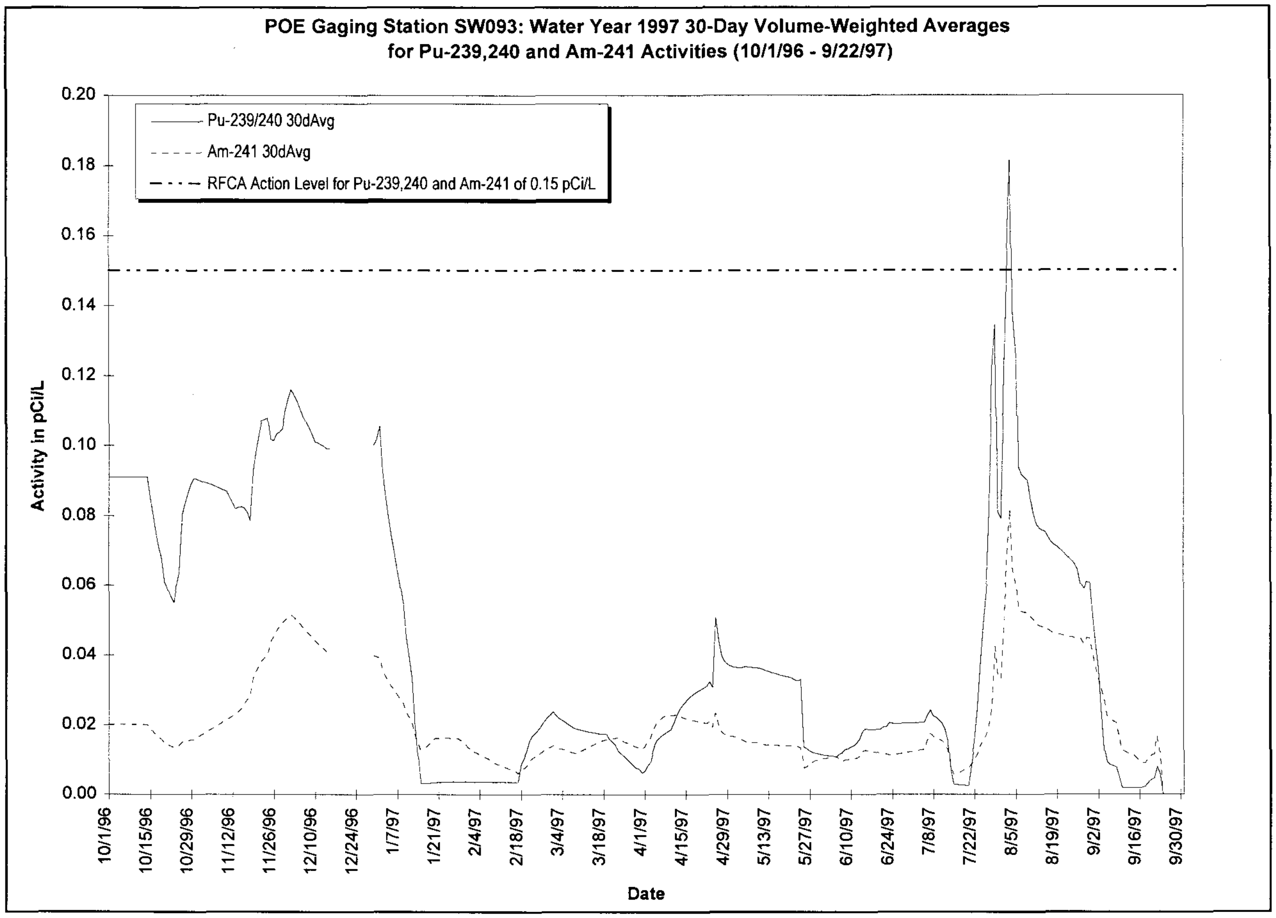

Figure 2-7. Gaging Station SW093 30-Day Averages: October 1, 1996 - September 22, 1997.

3. DATA SUMMARY AND ANALYSIS FOR GS03

All IA runoff and Wastewater Treatment Plant (WWTP) effluent tributary to Walnut Creek pass through the Terminal Ponds A-4 and B-5. Since discharges from A-4 (GS11) showed no elevated activities during the period of elevated activities at GS03 (as discussed in Section 2.2), it is assumed that source of the radionuclide activity at GS03 is downstream from the Terminal Ponds. Therefore, Progress Report #1 primarily included analysis and interpretation of environmental information for the GS03 drainage from the Site Terminal Ponds to Indiana Street, including tributaries. New information collected since Progress Report #1 is included in the following section. A cross-linked discussion of this information and the specific source location hypotheses they support or do not support are included in Section 4.2.

3.1. AUTOMATED SURFACE-WATER MONITORING DATA

This section presents data summary and analysis for environmental information collected at gaging stations GS03 (Walnut Creek at Indiana Street), GS08 (Pond B-5 outlet), and GS11 (Pond A-4 outlet) as shown in

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Figure 2-3. Data presented includes flow rates, discharge volumes, radionuclide activities, radionuclide loads, water-quality parameters, and precipitation. For Progress Report #1, analysis was performed on averages of all data available from WY93 to present, the continuous flow-paced samples from WY97, and the specific periods of recent elevated measurements[10]. The following section includes results from continuous flow-paced sampling since Progress Report #1. Although both Pu and Am were elevated at GS03, this section focuses on the transport and source location for Pu only. Analysis for both Pu and Am will be included in Progress Report #3 when assessing any downstream effects and risks associated with the increased transport of actinides.

3.1.1. Data Summary

Significant data exists for flow and radionuclide activities at the gaging stations of interest. Information for total suspended solids (TSS), metals, and major ions is limited. Additional information for these parameters will need to be collected should the progress of the source evaluation indicate the need. Individual results are averages of target, duplicate, and replicate results for each sample. Validated results which were rejected are not included. All activities are for total radionuclides.

Surface-Water Flow Rates and Discharge Volumes

Reliable flow records have been collected at GS03, GS08, and GS11 since WY93. Site Terminal Pond discharges to Walnut Creek represent an average of 68% of the volume annually measured at GS03. However, this average is highly influenced by the very high runoff volumes in WY95. For WY93, WY94, WY96, and WY97, the Terminal Pond discharges represent 96% of the annual volume measured at GS03. Variation of flow rates and discharge volumes is significant in Walnut Creek, and coincides with variation in precipitation (as shown on Figure 3-1 and Figure 3-2). Significant gains in flow rates are seen at GS03 for the Spring months as overland flow occurs in the drainage between the Terminal Ponds and GS03. Additionally, tributaries and seeps contribute relatively more water during these months.

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[10] Flow data is included for the period 10/1/92 - 9/30/97; analytical data is included for the period from 10/1/92 - 8/31/97.

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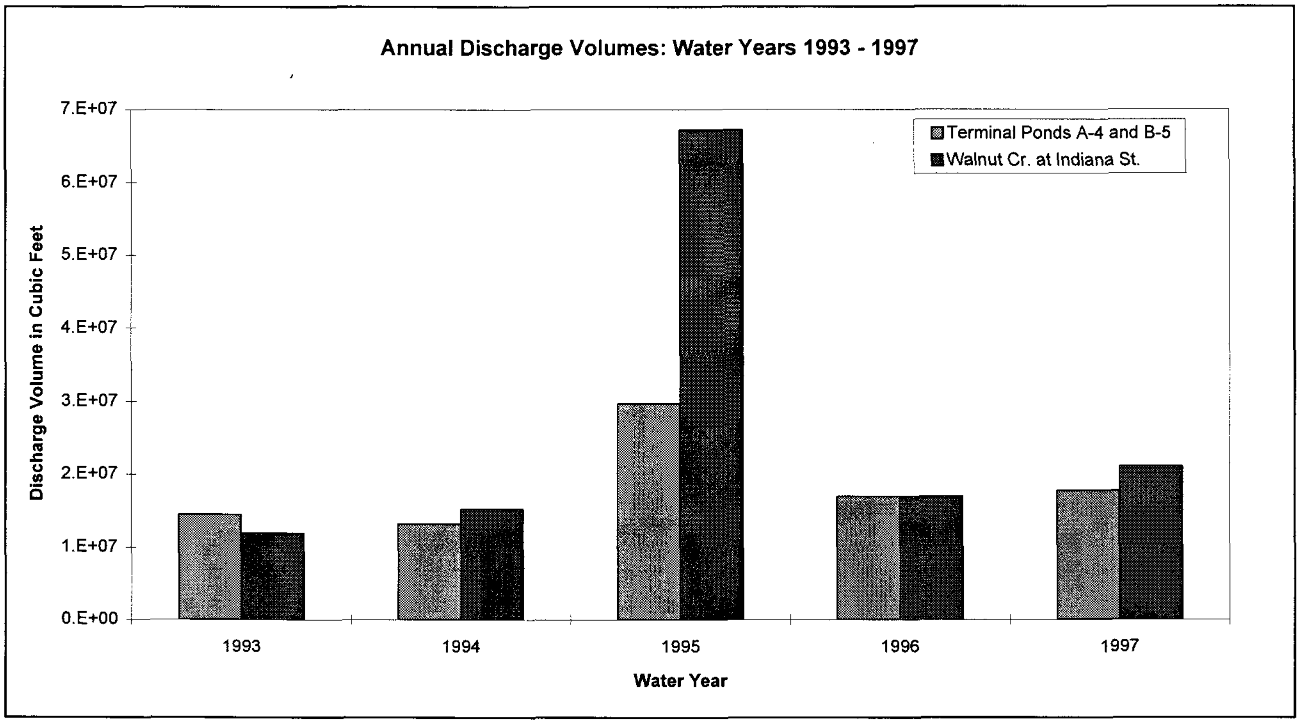

Figure 3-1. Annual Discharge Volumes for Walnut Creek.

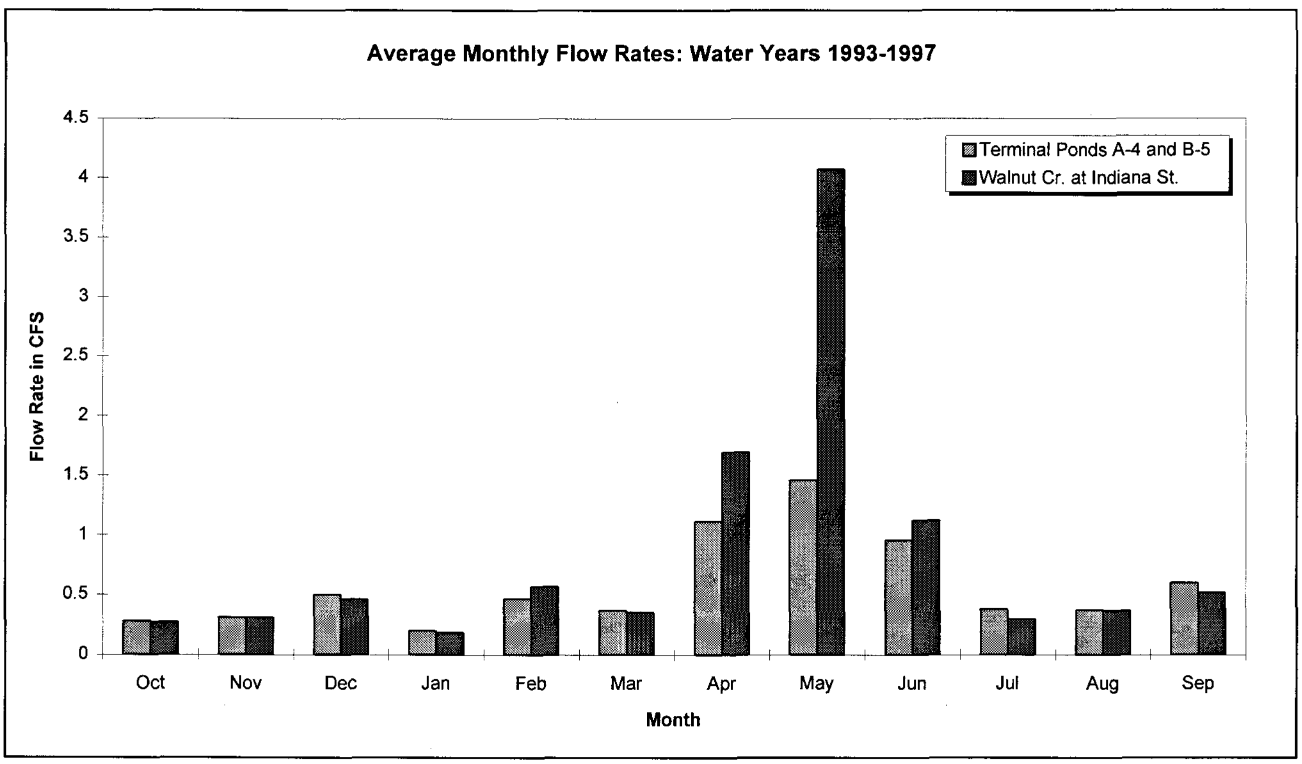

Figure 3-2. Average Monthly Flow Rates in Walnut Creek.

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Radionuclide Activities

Individual analytical results for Pu are shown in Figure 3-3. The higher values in WY95 for the Terminal Ponds were a result of very high runoff volumes and the subsequent emergency discharge of Ponds A-4 and B-5 before adequate settling of contaminants could be achieved. All sample results are plotted regardless of sampling protocol employed[11]. The recent elevated results at GS03 can be seen on the right side of the plot. The unusual magnitude of these measurements is apparent. Summary statistics for these results are shown in Table 3-1. These summary statistics indicate that there may be a decrease in water quality between the Terminal Ponds and Indiana Street. However, when the WY97 results are not included, the average activity at GS03 is not different than the average activities for the Terminal Ponds. Therefore, the drainage may have changed somehow to give the elevated values. It should be noted that these activities are arithmetic averages, which do not take into account the hydrologic conditions during sampling (storm-event, baseflow, etc.) or the flow rate (more importantly, the discharge volume) associated with the measured activity.

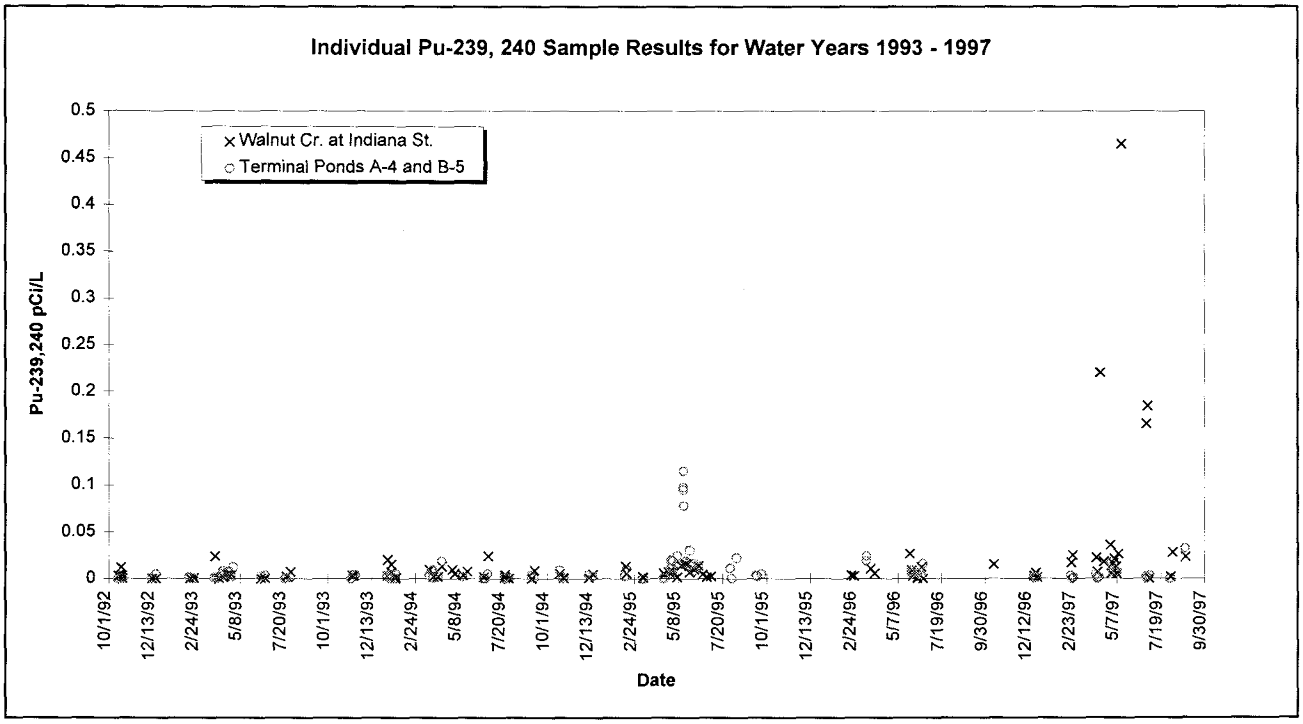

Figure 3-3. Individual Analytical Pu Results for Walnut Creek.

[11] Individual grabs, time-paced (scheduled grabs) composites, storm-event (hydrograph rising limb) flow-paced composites, and continuous flow-paced composites are shown. For a discussion of sample collection methods, see Section 6.2.4 in Progress Report #1.

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Table 3-1. Summary Statistics for Plutonium Samples from Pond A-4, Pond B-5, and Walnut Creek at Indiana Street.

Sampling Location[a]	Number of Samples	Average[b] Activity (pCi/L)	Maximum Result (pCi/L)	Standard Deviation[c] (pCi/L)
Walnut Creek at Indiana Street				
GS03	27	0.050	0.465	0.101
W+I	68	0.006	0.026	0.006
All	95	0.018	0.465	0.057
Pond A-4				
GS11	21	0.004	0.032	0.007
A4EFF	72	0.007	0.097	0.016
All	93	0.006	0.097	0.014
Pond B-5				
GS08	3	0.010	0.017	0.006
B5Eff	18	0.023	0.115	0.028
All	21	0.021	0.115	0.027

[a] Rocky Flats Environmental Database System location codes are shown; GS03 and W+I are co-located; GS11 and A4EFF are co-located; GS08 and B5EFF are co-located.

[b] Arithmetic average

[c] Assumes normal distribution

Figure 3-4 shows the relative average annual activities in Walnut Creek for WY93 - WY97. For WY93 - WY96, arithmetic averages are plotted. However, due to the continuous flow-paced sampling protocols currently in place, more representative volume-weighted average activities are shown for WY97. This volume-weighted average is calculated in a fashion similar to 30-day averages[4], except that the period is from October 1, 1996 to August 7, 1997.[12] It is important to note that although elevated measurements were made this year, the GS03 volume-weighted average for Pu is still below 0.05 pCi/L (0.036 pCi/L). Although average activities seem to have changed significantly, the changes are small when taken in context with the levels of activity (to less than 1/100th of a pCi). In fact, the apparent change in activity may be due to the change in sampling protocols, and not a reflection of actual changes in the drainage. This change in

[12] Each carboy has a load in pCi calculated from the activity and the associated creek discharge volume. The total load in pCi for all samples is then divided by the total creek discharge volume to give the volume-weighted activity in pCi/L. For periods where no activity was available for GS03 (NSQ), these periods were assigned the volume-weighted average activity of the non-NSQ periods. This allows for the calculation of loads for the entire period.

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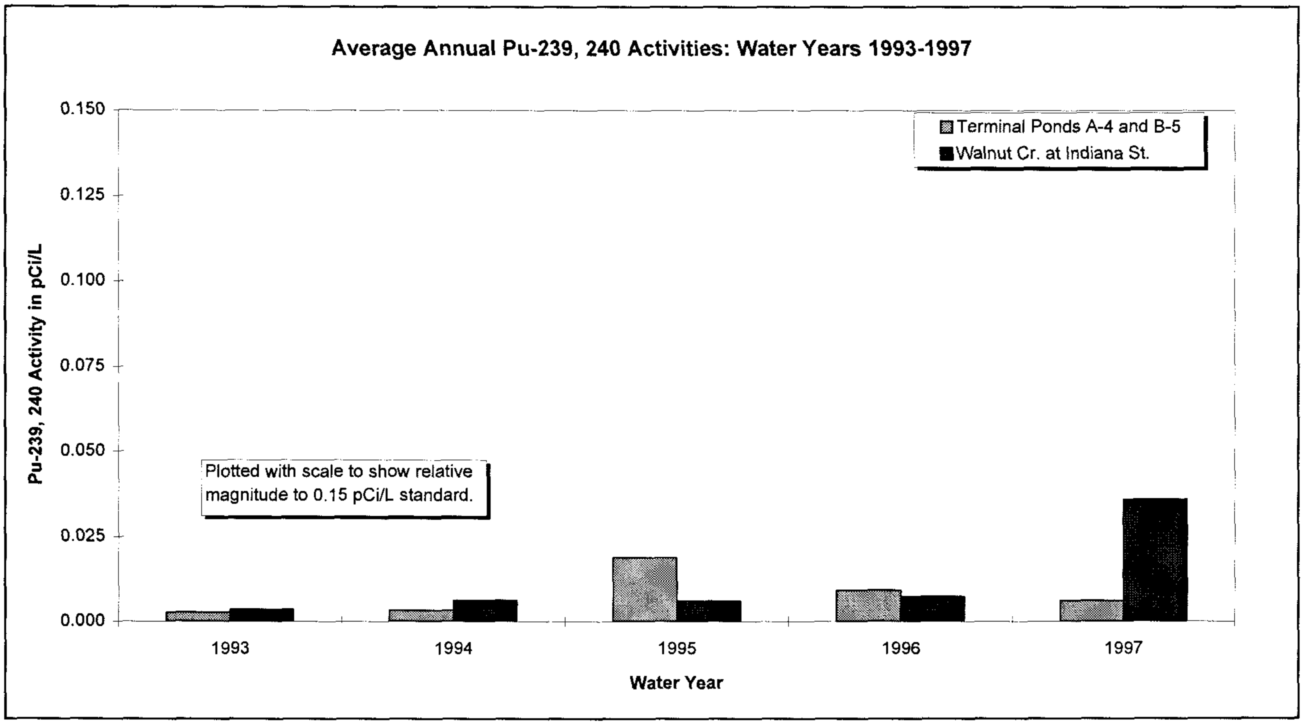
sampling protocols, from grab and storm-event sampling to continuous flow-paced sampling, was discussed further in Section 6.2.4 in Progress Report #1.



Volume-weighted WY97 average is plotted.

Figure 3-4. Average Annual Pu Activities for Walnut Creek.

It is generally agreed that Pu tends to form strong associations with particulate matter. If contaminated particles are transported in surface water, then the observed Pu levels could be correlated with the amount of TSS. The data collected at GS10 is a good example (Figure 3-5) of this phenomenon. During high intensity precipitation events, with increased raindrop impact, higher quantities of solids are transported in overland flow. Similarly, higher flow rates in ditches and creeks, generally result in increased TSS values due to higher flow velocity and turbulence. Additionally, seasonal changes in biological and chemical processes may influence Pu transport. Figure 3-6 shows monthly arithmetic average activities which increase for months with higher rainfall and flow rates which are shown on Figure 3-2.

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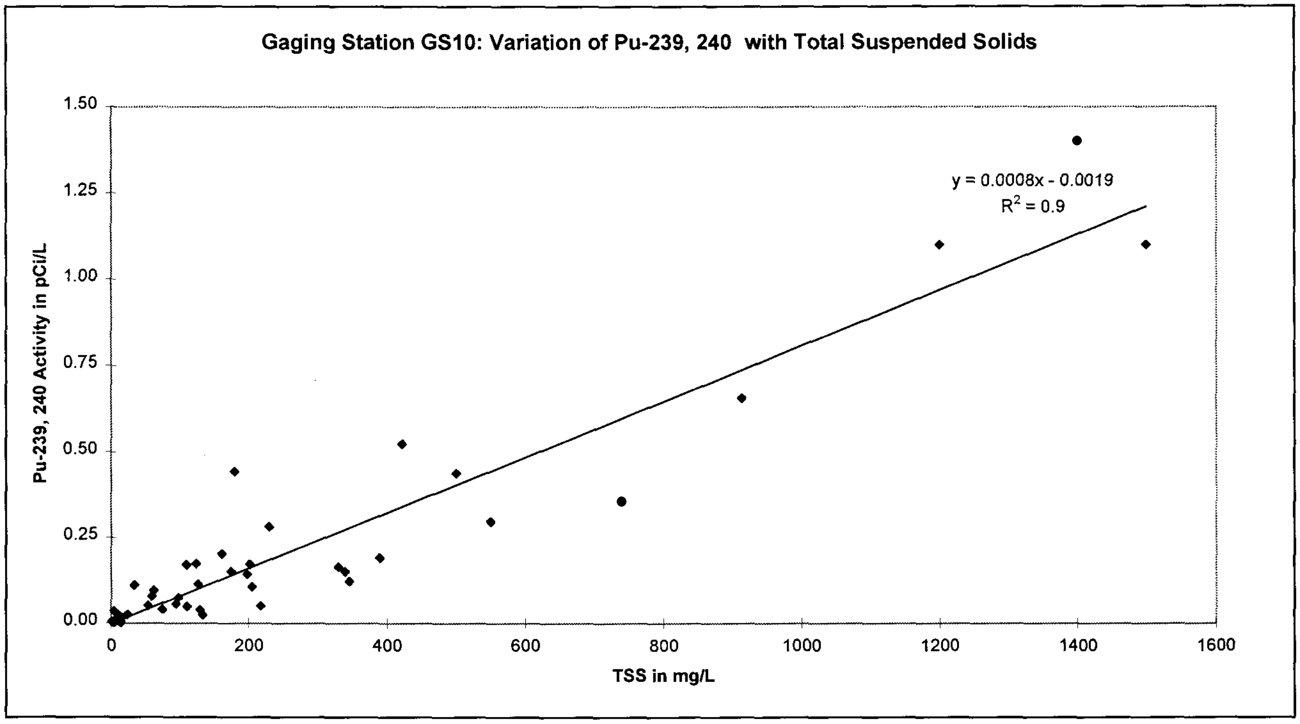
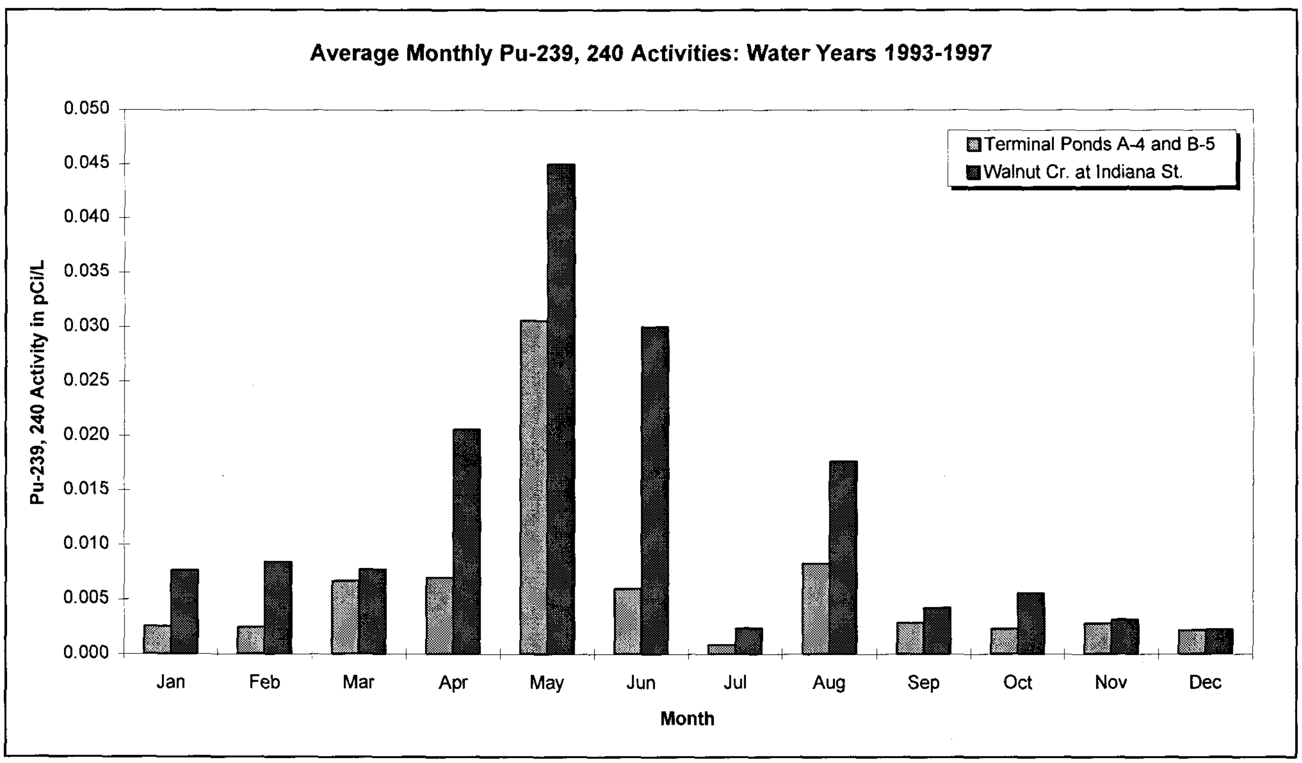


Figure 3-5. Variation of Pu with Total Suspended Solids at GS10.



All averages are arithmetic.

Figure 3-6. Average Monthly Pu Activities in Walnut Creek.

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3.1.2. Loading Analysis

WY93 - WY97 Monitoring Data

Annual loads in micrograms are plotted in Figure 3-7. For WY93 - WY96, the arithmetic average activity is multiplied by the associated total annual discharge volume, then converted to micrograms. For WY97, the activity for each flow-paced composite is multiplied by the associated discharge volume, then converted to micrograms and totaled.

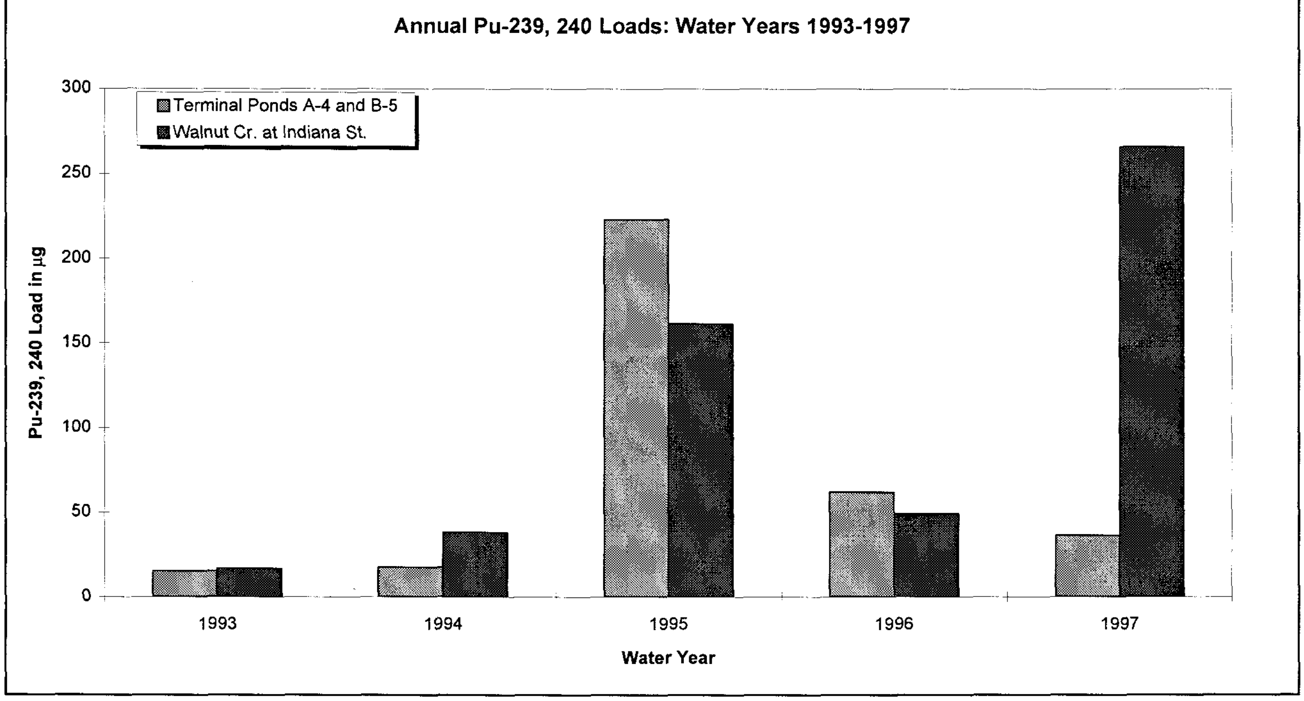

Figure 3-7. Annual Pu Loads in Walnut Creek.

The annual gain/loss in Pu load between the Terminal Ponds and Indiana Street is plotted in Figure 3-8. Losses in load are plotted as negative values. A gain indicates that Pu entered the stream reach between the Terminal Ponds and Indiana Street. A loss indicates that Pu was lost to the streambed or to the sediments in the GS03 flume pond. The result for WY97 indicates that a source may exist in the reach below the Terminal Ponds.

Seasonal loads in micrograms are plotted in Figure 3-9. For all water years, the seasonal arithmetic average activity is multiplied by the associated average seasonal discharge volume, then converted to micrograms.

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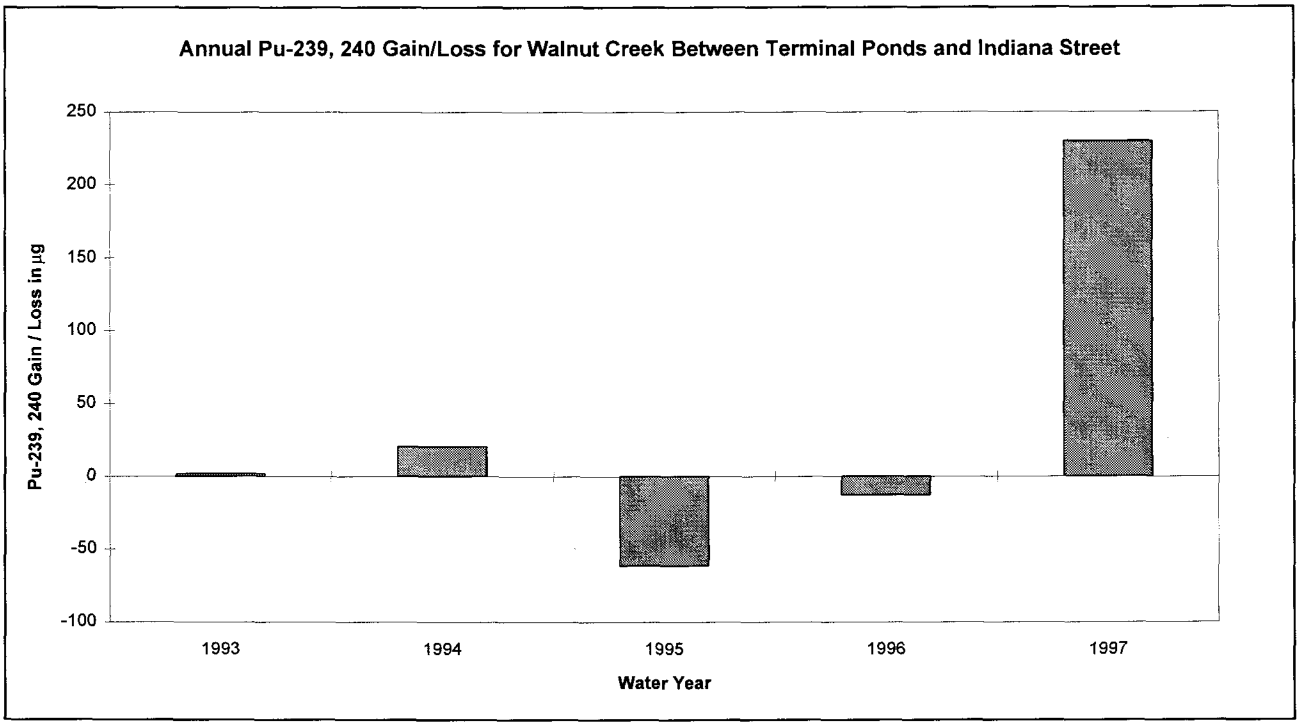

Figure 3-8. Annual Gain/Loss of Pu for Walnut Creek.

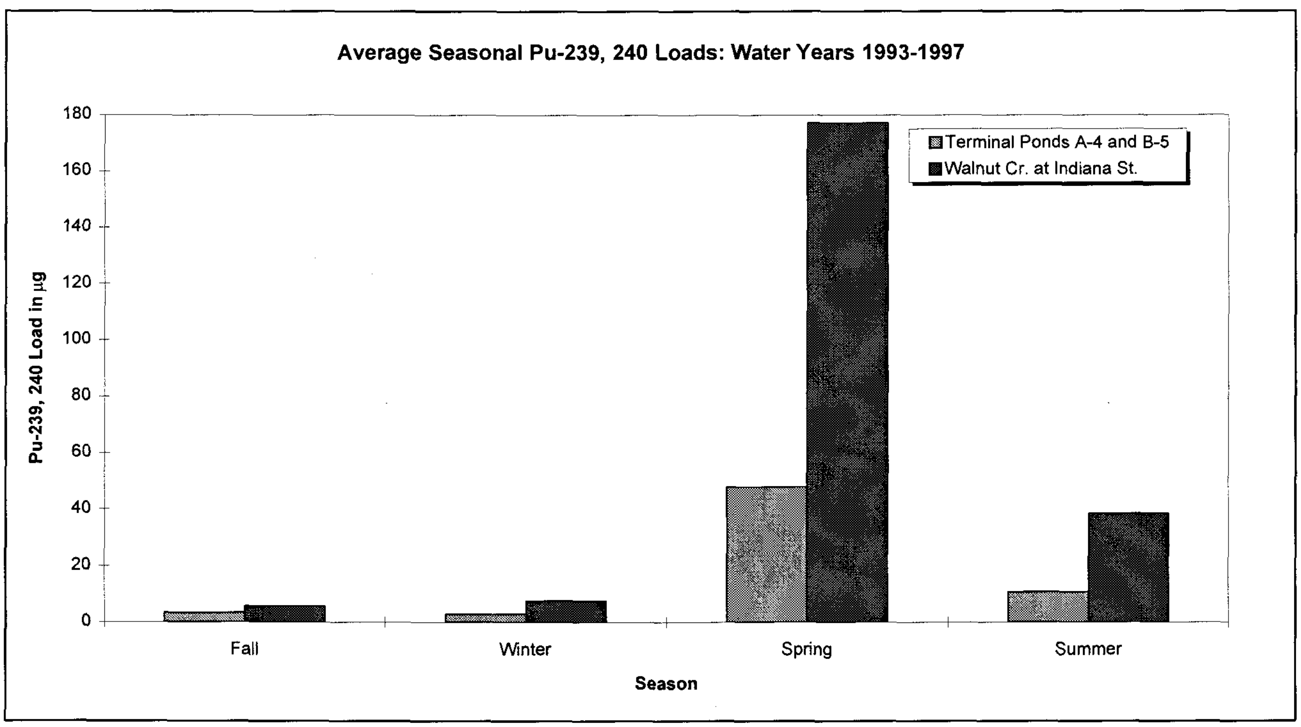

Figure 3-9. Seasonal Pu Loads in Walnut Creek.

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The seasonal gain in Pu load between the Terminal Ponds and Indiana Street is plotted in Figure 3-10. A gain indicates that Pu entered the stream reach between the Terminal Ponds and Indiana Street. The largest gain occurs during periods of higher precipitation and the associated overland flow and increased flow rates.

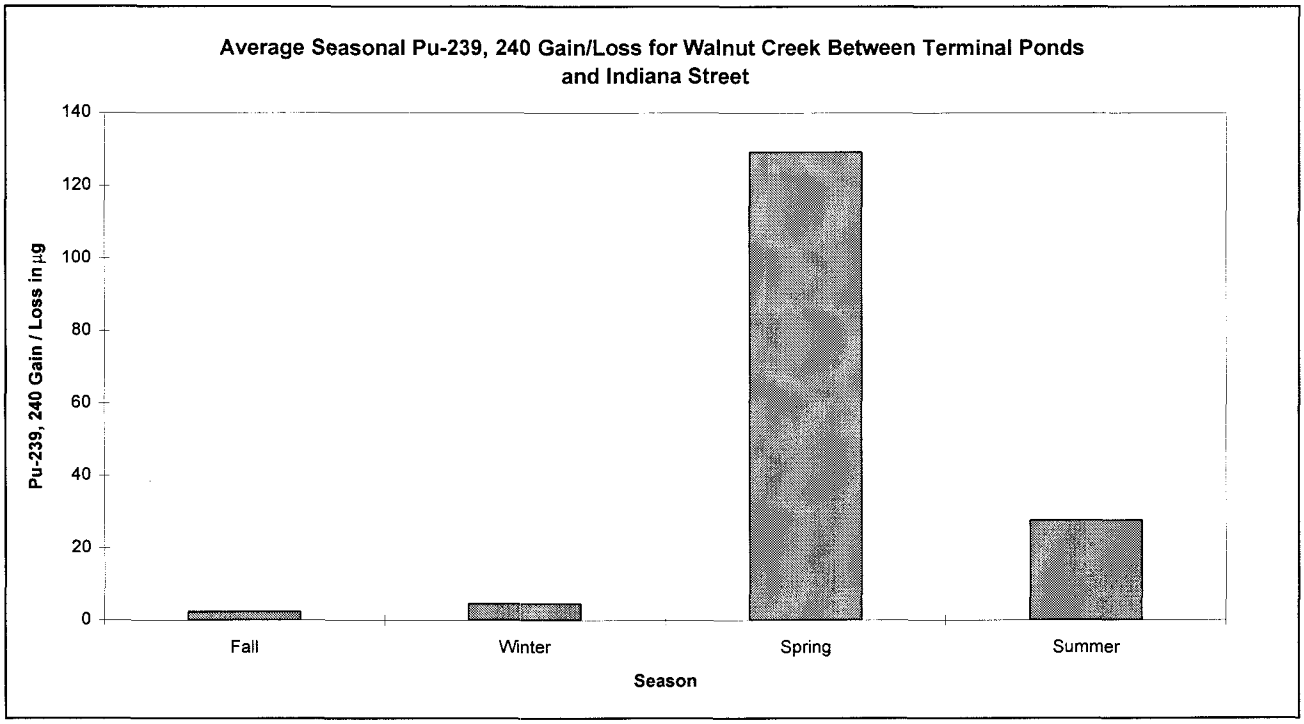

Figure 3-10. Seasonal Gain/Loss of Pu for Walnut Creek.

WY97 Continuous Flow-Paced Monitoring Data

Figure 3-11 shows volume-weighted average monthly activities for continuous flow-paced samples collected in WY97. Analytical results are available through August 31, 1997. For all months, the activity increases between the Terminal Ponds and Indiana Street.

Detail for each continuous flow-paced composite sample at GS03 is presented in Table 3-2. Elevated samples are indicated in bold. Detail for each continuous flow-paced composite sample at GS08 is presented in Table 3-3. Detail for each continuous flow-paced composite sample at GS11 is presented in Table 3-4. It is important to note the highly variable activity for the GS03 samples, especially for the three consecutive samples collected during a pond discharge during the period June 25, 1997 - July 6, 1997 which shows that the activity drops off dramatically for the last sample. This seems to indicate a very intermittent source, a very localized source, or some sort of 'hot particle' mechanism. Regardless, it is apparent that the variability of surface-water activity and the transport mechanisms for Pu are not fully understood.

Table 3-2. Sample Detail for GS03.

Sample Start Time	Sample End Time	Discharge Volume During Sample (cubic feet)	Pu-239, 240 Activity (pCi/L)	Pu-239, 240 Load (micrograms)
10/1/96 0:00[a]	None	1481303	*0.036*	21.21
10/14/96 14:38	12/20/96 12:16	69687	0.015	0.42
12/20/96 12:16	12/23/96 11:39	610219	0.003	0.73
12/23/96 11:39	12/26/96 12:13	440743	0.006	1.05
12/26/96 12:13	12/30/96 14:32	124911	0.001	0.05
2/20/97 14:21	2/22/97 15:39	609170	0.017	4.13
2/22/97 15:39	3/3/97 11:08	1101256	0.025	10.98
3/3/97 11:08	4/3; NSQ[b]	9699	*0.036*	0.14
4/3/97 12:47	4/5/97 16:37	470746	0.022	4.13
4/5/97 16:37	4/8/97 17:12	624135	0.007	1.74
4/8/97 17:12	**4/15/97 11:16**	709435	**0.220**	62.26
4/15/97 11:16	4/26/97 16:28	1265362	0.018	9.09
4/26/97 16:28	4/28/97 13:57	2054116	0.036	29.50
4/28/97 13:57	5/1/97 16:25	1010904	0.005	2.02
5/1/97 16:25	5/3/97 14:07	1139103	0.016	7.27
5/3/97 14:07	5/6/97 12:04	1479879	0.021	12.40
5/6/97 12:04	5/7/97 13:16	442806	0.013	2.30
5/7/97 13:16	5/9/97 14:50	692467	0.005	1.38
5/9/97 14:50	5/15/97 7:40	1077900	0.027	11.39
5/15/97 7:40	**6/25/97 15:15**	45743	**0.465**	8.48
6/25/97 15:15	**6/27/97 13:35**	378015	**0.165**	24.88
6/27/97 13:35	**7/1/97 14:07**	719360	**0.184**	52.80
7/1/97 14:07	7/6/97 17:14	547709	0.000	0.00
7/6/97 17:14	8/5; NSQ[b]	13939	*0.036*	0.20
8/5/97 14:24	8/8/97 7:57	724257	0.002	0.58
8/8/97 7:57	8/29/97 12:55	47023	0.028	0.53
8/29/97 12:55	9/1/97 10:17	760556	0.023	6.98

[a] Sampling began on 10/14/96, after the completion of a B-5 discharge started in FY96, activity set to volume-weighted average to date for loading calculation purposes.
[b] Sample had insufficient volume for analysis, activity set to volume-weighted average to date for loading calculation purposes.
Elevated samples are indicated in bold.

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Table 3-3. Sample Detail for GS08.

Sample Start Time	Sample End Time	Discharge Volume During Sample (cubic feet)	Pu-239, 240 Activity (pCi/L)	Pu-239, 240 Load (micrograms)
10/1/96 0:00[a]	10/10/96 10:15	1535344	*0.010*	6.28
4/28/97 12:02	5/1/97 10:08	718814	0.017	4.87
5/1/97 10:08	5/6/97 14:51	658154	0.006	1.58
5/6/97 14:51	5/12/97 14:33	688436	0.008	2.20

[a] B-5 discharge started in FY96 was not sampled, activity set to volume-weighted average to date for loading calculation purposes.

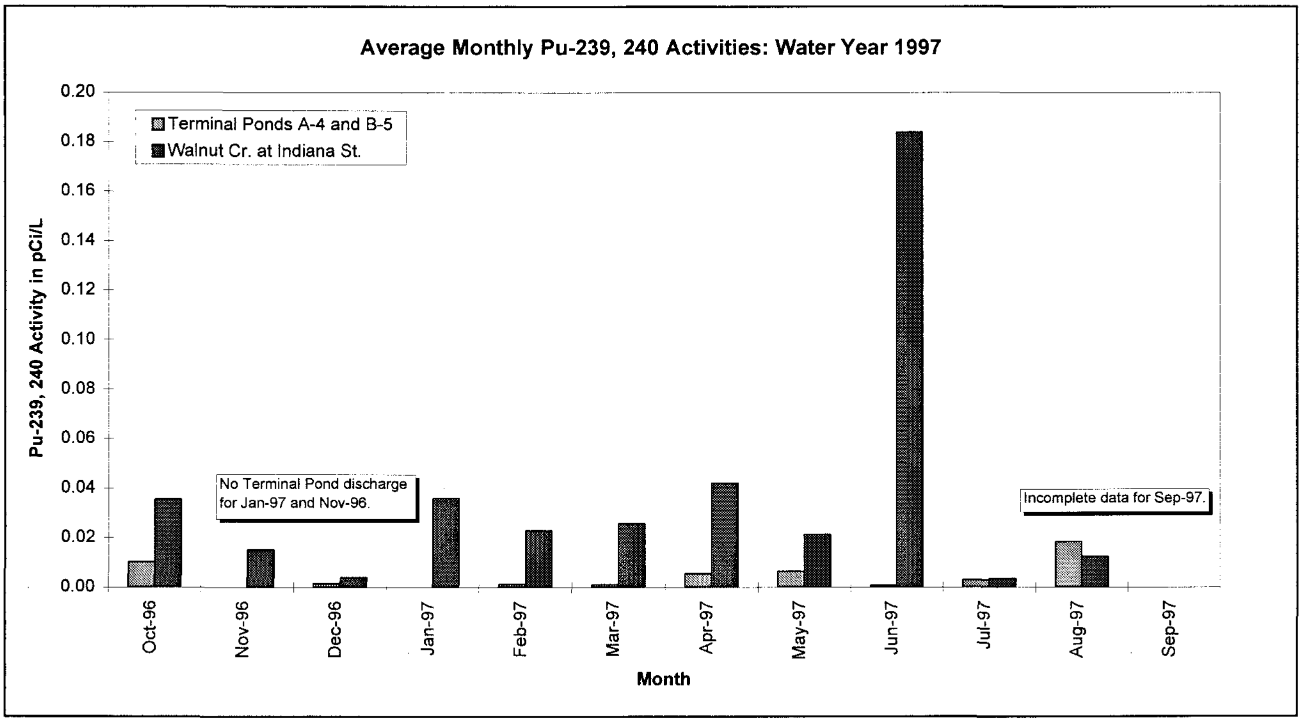

Figure 3-11. Average Monthly Pu Activities in Walnut Creek.

Table 3-4. Sample Detail for GS11.

Sample Start Time	Sample End Time	Discharge Volume During Sample (cubic feet)	Pu-239, 240 Activity (pCi/L)	Pu-239, 240 Load (micrograms)
12/20/96 8:05	12/23/96 8:58	705648	0.001	0.28
12/23/96 8:58	12/26/96 9:07	462124	0.002	0.37
12/26/96 9:07	12/28/96 7:17	105866	0.001	0.04
2/20/97 10:01	2/22/97 13:42	675876	0.003	0.81
2/22/97 13:42	2/25/97 13:52	685803	0.000	0.00
2/25/97 13:52	3/2/97 14:48	395895	0.001	0.16
4/3/97 10:08	4/5/97 16:12	552740	0.004	0.88
4/5/97 16:12	4/8/97 14:31	592151	0.000	0.00
4/8/97 14:31	4/13/97 11:11	665231	0.001	0.27
5/1/97 15:26	5/6/97 13:53	1952671	0.006	4.67
5/6/97 13:53	5/8/97 12:14	514592	0.006	1.23
5/8/97 12:14	5/14/97 11:46	957148	0.006	2.29
6/25/97 13:44	6/27/97 13:15	457604	0.002	0.37
6/27/97 13:15	7/1/97 13:49	758314	0.000	0.00
7/1/97 13:49	7/6/97 8:19	564141	0.003	0.68
8/5/97 11:15	8/7/97 15:14	568103	0.000	0.00
8/29/97 10:02	9/1/97 9:32	885503	0.032	11.30

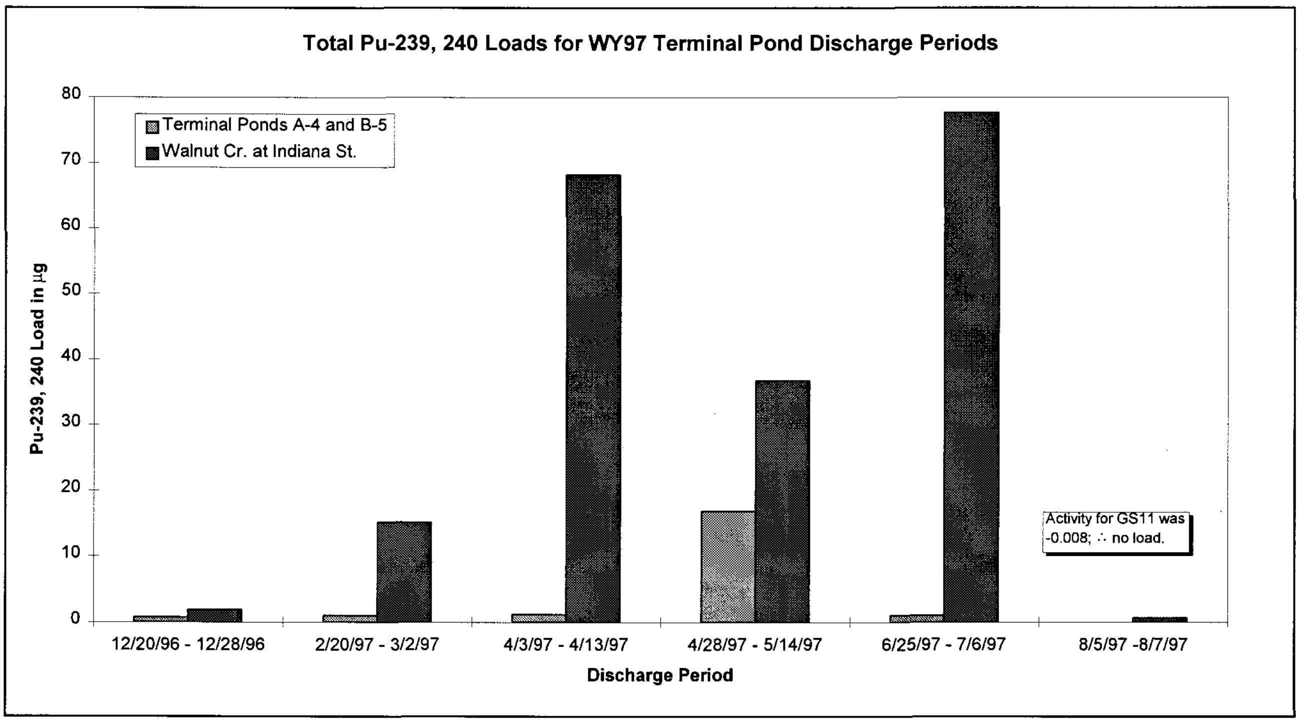

Figure 3-12. Walnut Creek Loads During WY97 Terminal Pond Discharges.

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Loads were calculated during Terminal Pond discharges to evaluate changes in loads as the discharge moved through the reach to Indiana Street. Figure 3-12 shows that for all discharges in WY97, loads increased between the Terminal Ponds and Indiana Street, indicative of a source in the drainage below the Terminal Ponds, or a tributary surface-water source. Complete analytical results for the August 29 - September 8, 1997 Pond A-4 discharge have not been received from the labs.

3.1.3. Data Correlations

Flow Rates

As stated previously, Pu tends to form strong associations with particulate matter (as shown in Figure 3-5). If these particles are transported in surface water, then so is Pu. During high intensity precipitation events, with increased raindrop impact, higher quantities of solids are transported in overland flow. Similarly, higher flow rates in ditches and creeks, generally result in increased TSS values due to higher flow velocity and turbulence. Unfortunately, very few results exist for TSS at GS03. Recent sampling at GS03 has included TSS analysis, although results are often very low. Figure 3-13 shows the variation of Pu with TSS for recent samples collected at GS03. There are insufficient data to form a correlation. Results below the MDA of 5 mg/L TSS are not plotted.

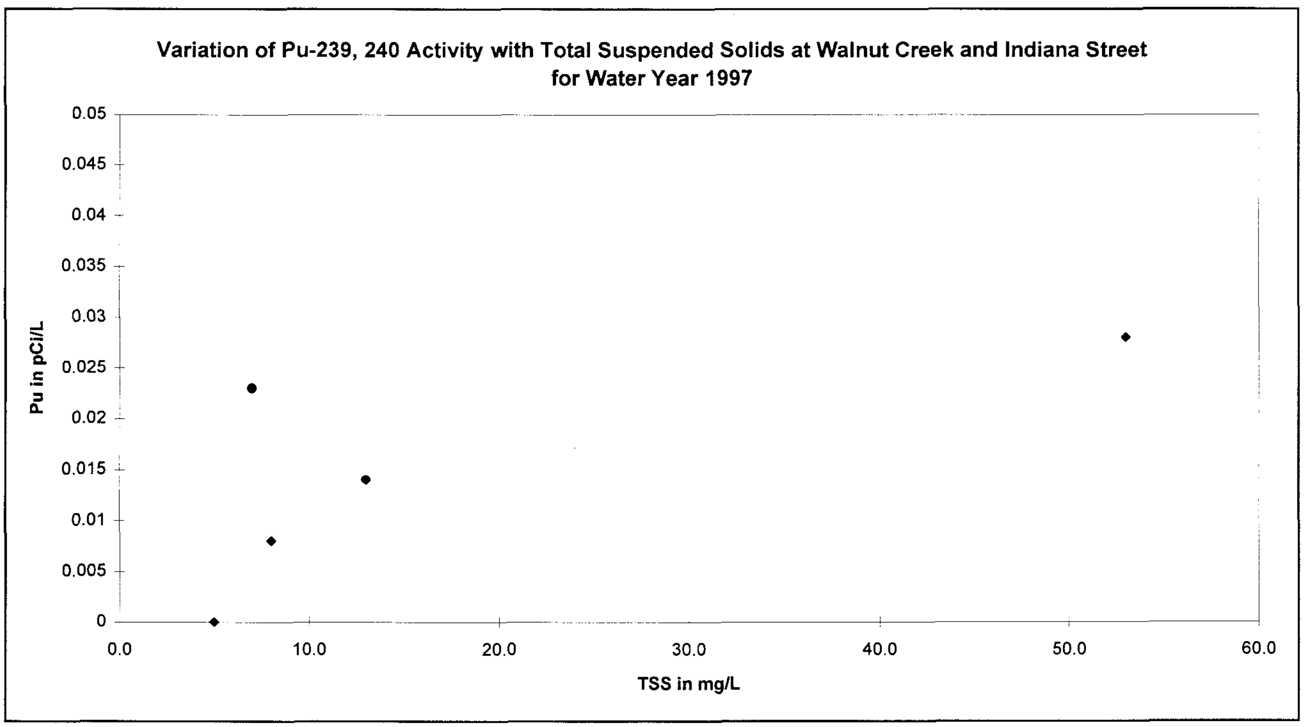

Figure 3-13. Variation of Pu with TSS at GS03.

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Figure 3-14 shows the variation of Pu activity with flow for GS03. The activity plotted is the analytical result for the sample; the flow is the average of the flow rates during each composite grab. Figure 3-14 shows no trends that are indicative of a Pu source influenced solely by flow rate. An upward trend generally indicates the increased movement of Pu during higher flow rates. This can occur when the source is widespread (movement through increased overland flow), or when the source exists in the streambed itself (movement through increased scouring). These are the mechanisms commonly seen at other Site monitoring locations. A downward trend may indicate that groundwater is the source. For example, during low flow rates a contaminated groundwater source could make up the larger proportion of the flow and result in higher activities. During runoff or pond discharges where relatively cleaner water enters the creek, the groundwater source would be diluted, resulting in lower activities. Figure 3-14 seems to indicate that neither of these mechanisms are present. However, it may also indicate that there are multiple, potentially intermittent, mechanisms and sources.

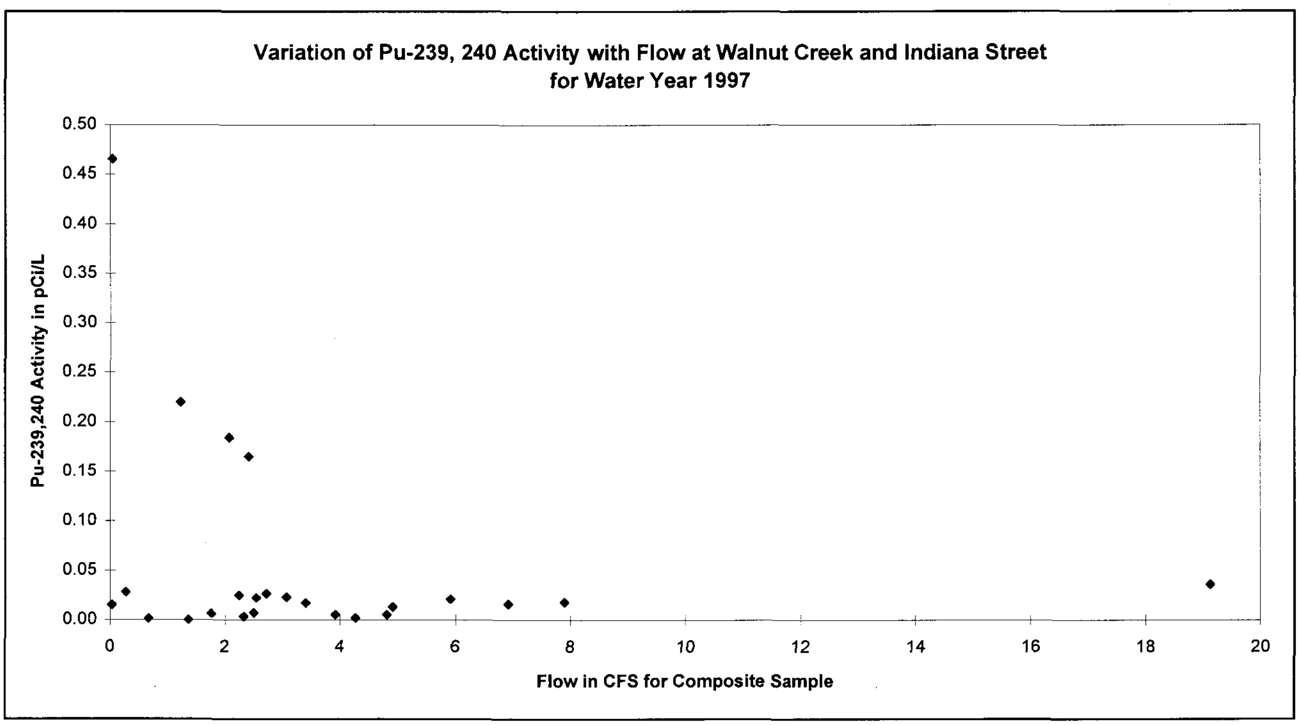

Figure 3-14. Variation of Pu Activity with Flow Rate at GS03.

3.2. SYNOPTIC SAMPLING EVENT FOR GS03 DRAINAGE

Seven temporary monitoring locations were installed to synoptically sample the first 24 hours of an A-4 discharge (August 29-30, 1997) at various locations along Walnut Creek between Pond A-4 and GS03 (shown in Figure 3-15). Automatic samplers were used to collect 75 time-paced grabs (at 20-minute

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intervals) in a 15-liter composite carboy. The samplers were spaced along Walnut Creek to determine spatial variability in water quality. Since discharge could not be measured at each location, each sampler was started as the discharge reached its sample intake, effectively sampling the same 'plug' of water. Each composite sample was analyzed for total radionuclides, total metals, dissolved metals, TSS/total dissolved solids (TDS), hardness, and sand silt split. Additionally, field grab samples for total organic carbon/dissolved organic carbon (TOC/DOC) were collected at the start time of each composite sample. Results for selected parameters are given in Table 3-5.

Since each sampler effectively sampled the same 'plug' of water, a comparison of activity will indicate a corresponding change in load. Figure 3-16 shows the hydrograph for the sampling event. Location 16597 is the most upstream location, while location 15497 is the most downstream. Surface-water radionuclide activities from these samples do not indicate significant spatial variability (Figure 3-17). Although there appears to be a slight increase in activity with downstream position, the low activities do not indicate a significant localized source.

No significant correlations between Pu activities and the water-quality parameters in Table 3-5 were determined which may have indicated transport mechanisms and the location of source areas.

Table 3-5. Analytical Results for Selected Parameters from Walnut Creek Synoptic Event.

Location Code	Sample Date	TOC mg/L	TSS mg/L	Al µg/L	Fe µg/L	Mn µg/L	Pu-239,240 pCi/L	Pu Error pCi/L
16597	8/29/97	16.0	2.5[a]	41.0	54.4	11.5	0.007	0.004
16197	8/29/97	11.0	5.0	98.6	110	14.8	-0.002	0.008
15997	8/29/97	12.0	9.0	210	195	16.3	0.009	0.006
15797	8/29/97	13.0	2.5[a]	70.4	77.5	10.2	0.019	0.004
15597	8/29/97	12.0	5.0	213	238	20.4	-0.002	0.008
17097	8/29/97	11.0	8.0	100	159	29.9	-0.003	0.01
15497	8/29/97	11.0	9.0	144	182	36.7	0.042	0.0001
GS11	8/29/97[b]	NA	NA	NA	NA	NA	0.032	0.003
GS03	8/29/97[c]	NA	7.0	NA	NA	NA	0.023	0.004

[a] Result was less than the MDA of 5.0 mg/L; set to 2.5 for correlation purposes
[b] Flow-paced composite from 8/29 - 9/1/97
[c] Flow-paced composite from 8/29 - 9/4/97

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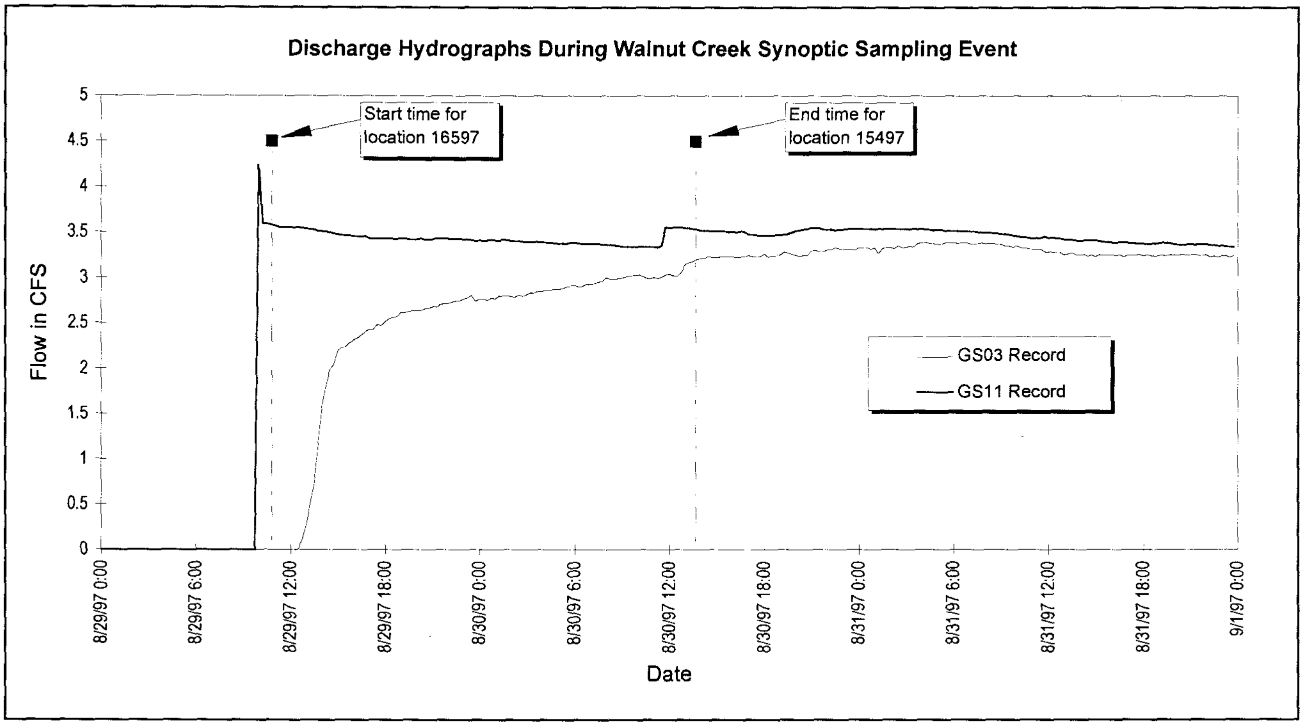

Figure 3-16. Walnut Creek Hydrographs During Synoptic Sampling Event: August 29-30, 1997.

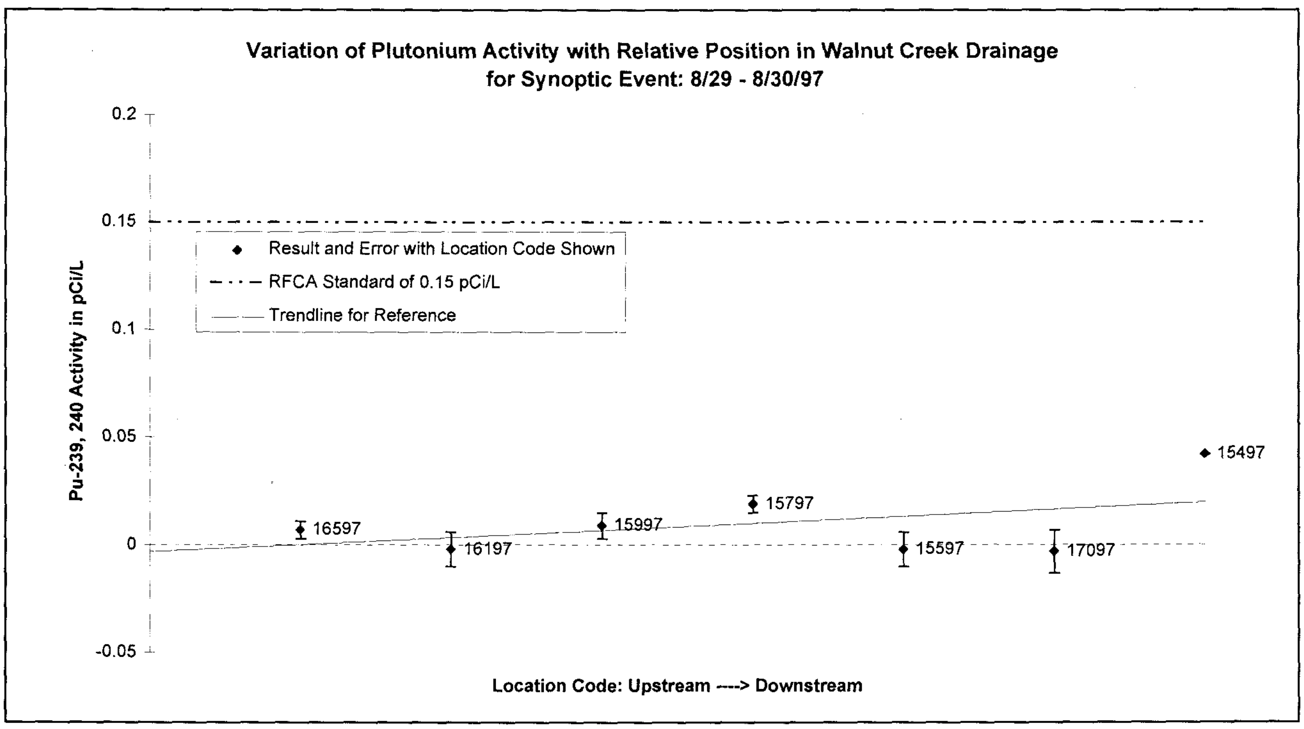

Figure 3-17. Plutonium Results for Walnut Creek Synoptic Sampling Event.

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3.3. RECENT SEDIMENT SAMPLING

Sediment samples were collected on August 21, 1997 at 19 locations along Walnut Creek (shown on Figure 3-18). The intent of this sampling was to evaluate for spatial variability which may indicate the existence of newly exposed legacy contaminated sediments or a tributary contributing contaminated sediments through overland runoff. Samples were analyzed for Pu, U, and Am (Table 3-6). Locations 16997, 16897, and 16797 are located on No Name Gulch at Walnut Creek, North Walnut Creek below A-4, and South Walnut Creek below B-5, respectively. The range in values for these locations is not surprising, with the highest value in South Walnut Creek. A comparison of 16397 (Walnut Creek just above the McKay Ditch) and 16497 (McKay Ditch just above Walnut Creek) indicates that main Walnut Creek has higher sediment activities than tributaries such as McKay. The simple arithmetic average of all results (with negative values set to zero) is 0.27 pCi/g. If it is assumed that the Pu is associated with sediments and surface-water TSS on a strictly mass to mass ratio, 1850 mg/L of TSS at 0.27 pCi/g would be required to give an activity of 0.5 pCi/L at GS03. This level of TSS far exceeds any value measured at GS03. This indicates that the particles most associated with Pu may be preferentially suspended and transported in surface-water runoff.

Sediment sampling results from the flume pond and the main Walnut Creek drainage pathway tributary to GS03 are plotted in Figure 3-19. A decreasing trend in sediment activity can be seen while moving downstream in the drainage. Assuming historic Site IA surface-water releases and aerial contamination are the source of distributed contamination in lower Walnut Creek, this dispersion effect is plausible.

A small flume pond is located on the Walnut Creek drainage immediately west of and upstream from Indiana Street. The pond was constructed in October 1978, and is used to measure Walnut Creek flow. Aerial photographs of the Walnut Creek drainage show a small pond at the Walnut Creek and Indiana location prior to 1978. This was most likely due to vegetation and sediment blocking the channel flowing under Indiana Street, causing the water to accumulate in the ditch to the west. At one point, the channel was cleared of debris and the pond shrunk.[13,14] This is consistent with the aerial photographs, which show the pond decreasing in size from the late 1960's to the mid 1970's. Assuming that this pond had received contaminated surface water and sediment associated with historic Site releases, especially discharges and construction activities in the B-Series, the pond and sediments surrounding the pond may contain legacy contamination.

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[13] Personal Communication, Daryl D. Hornbacher, Retired RFP Employee, September 18,1997.

[14] Personal Communication, Ralph Hawes, Retired RFP Employee, September 18, 1997.

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Table 3-6. Pu Results for Recent Sediment Sampling in Walnut Creek.

Location Code	Pu-239,240 pCi/g	Pu Error pCi/g
16997	-0.014	0.017
16897	0.164	0.061
16797	2.32	0.328
16697	0.375	0.1
16597	0.126	0.035
16397	0.817	0.143
16297	0.043	0.025
16197	0.322	0.077
16097	0.131	0.04
15997	0.089	0.056
15897	0.102	0.041
15797	0.022	0.084
15697	0.022	0.022
15597	0.253	0.065
15397	0.139	0.044
15297	0.045	0.015
15197	0.141	0.052
15497	0.009	0.025
16497	0.018	0.036

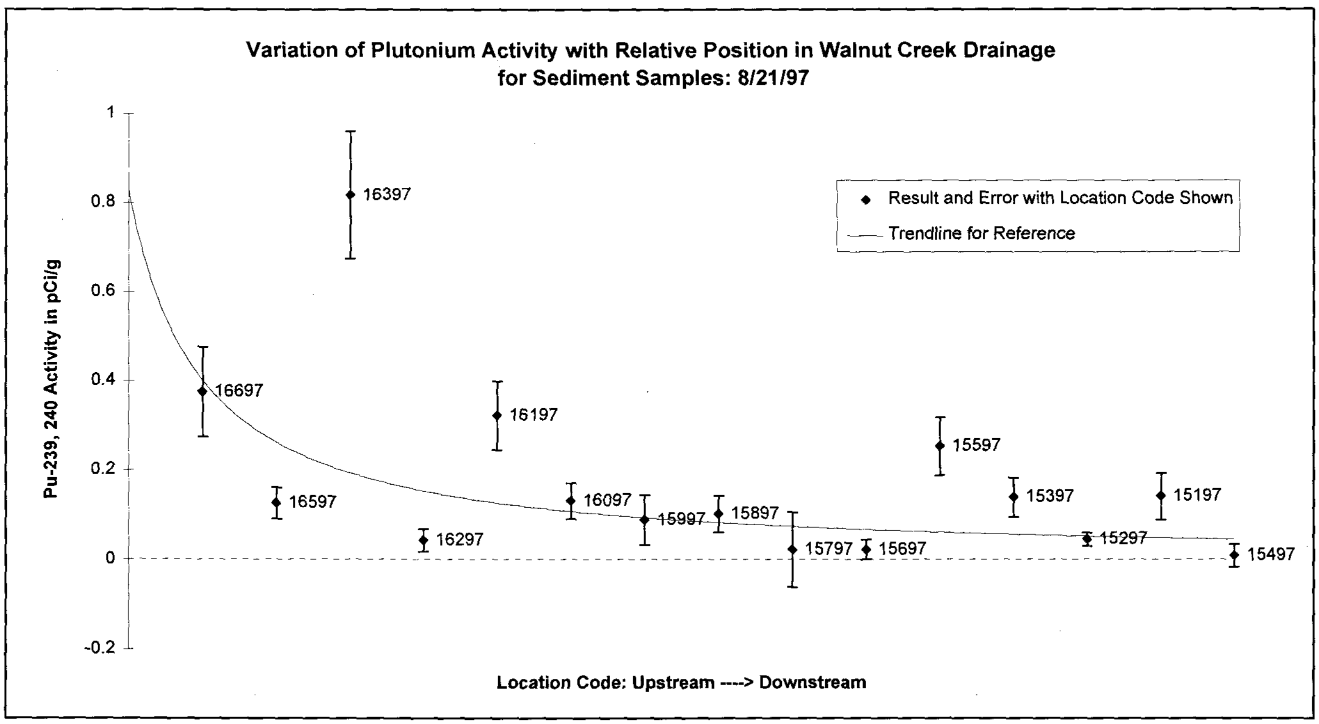

Figure 3-19. Plutonium Results for Recent Walnut Creek Sediment Sampling.

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The fact that this pond has been 're-worked' in the past, coupled with the intermittent nature of the elevated measurements at GS03, and the recent erosion (flood of May 1995) of the dam structure itself, points toward the dam materials as a possible source of contamination (See Section 5.2 of Progress Report #1). Accordingly, soil samples were collected from the eroded dam materials immediately north and south of the GS03 flume on September 9, 1997. Non-validated results show low levels of soil activity (Table 3-7).

Table 3-7. Soil Activity from GS03 Flume Pond Dam Materials.

Location Code	Pu-239,240 pCi/g	Pu Error pCi/g
17197; North	0.023	0.025
17297; South	0.071	0.049

Existing surface soil and sediment results for locations tributary to GS03 are shown in Figure 3-20. The Site is currently developing a Sampling and Analysis Plan for additional soil and sediment sampling to fill data gaps in the GS03 drainage and allow for the development of soil/sediment isopleths. These isopleths will subsequently be incorporated into a model as part of the Actinide Migration Studies (see detail in Section 9.6) which will predict overland transport of actinides. Additional soil and sediment sampling may also be collected to support ongoing source evaluations. These samples will be targeted to further define any localized source areas.

4. DATA SUMMARY AND ANALYSIS FOR GS10

4.1. WALK-DOWN OF DRAINAGE AREA

As part of the Source Evaluation for GS10, a walk-down was performed of the drainage area tributary to GS10 (Figure 4-1). The purpose of the walk-down was to visually identify conditions which may have indicated source areas contributing to the elevated readings. Conditions which might indicate a potential source area include the following items:

- Existence of man-made materials in drainage pathways;
- Areas of concentrated fine sediments in drainage pathways;
- Areas which contribute significant quantities of runoff sediment (e.g., steep dirt roads, barren hillsides, and slopes needing revegetation);
- Erosion on radionuclide-related Individual Hazardous Substance Sites (IHSSs);
- Position of radionuclide-related IHSSs in relation to storm water drainage pathways; and
- Overall condition of storm drainage pathways.

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The walk-down revealed no evidence of any man-made materials in the drainage pathways that indicate an uncontrolled release of contaminants. The drainage for GS10 is highly industrialized, and accordingly there is a multitude of possible sources of contamination, including numerous Pu-related IHSSs (discussed in detail in Section 4.7). Many areas exhibited signs of high flows. Flows were large enough to breach stream banks. The erosion of the channel was typical of a "washout" that occurs during frequent periods of high flows due to the impervious areas in the drainage. Surrounding dirt roads and hillsides showed signs of runoff erosion, and many areas lacked vegetation to control erosion.

4.2. AUTOMATED SURFACE-WATER MONITORING DATA

4.2.1. Data Summary

Significant data exists for flow and radionuclide activities at the gaging stations of interest. Information for TSS, metals, major ions, etc. is more limited. Additional information for these parameters will need to be collected if needed. Individual results are averages of target, duplicate, and replicate results for each sample. Validated results which were rejected are not included. All activities are for total radionuclides.

Surface-Water Flow Rates and Discharge Volumes

A reliable flow record has been collected at GS10 since WY93. Flow record has been collected at SW022, GS27, and GS28 since the Spring of 1995. Monitoring was terminated at GS28 in August of 1997 after this location had completed its Performance Monitoring requirements. Flow data included in this Progress Report for GS10, SW022, and GS27 ends on September 30, 1997. Relative average annual discharge percent to GS10 for SW022, GS27, and GS28 is 31%, 0.28%, and 1.11% respectively. However, during very high runoff events, the Central Avenue Ditch overflows through a corrugated metal pipe directly to GS10, short-circuiting SW022 (see Figure 2-1). Consequently, discharge and load associated with the Central Avenue Ditch drainage will be slightly underestimated in the following analysis. Variation of flow rates and discharge volumes is significant at GS10, and coincides with variation in precipitation (as shown on Figure 4-2 and Figure 4-3). Baseflow at GS10 is continuous and near constant year-round.

Radionuclide Activities

Individual analytical results for Pu at the gaging stations of interest are shown in Figure 4-4 through Figure 4-7. All sample results are plotted regardless of sampling protocol employed[15]. The large variation in activities is evident in these plots. Summary statistics for these results are shown in Table 4-1. These activities are arithmetic averages, which do not take into account the hydrologic conditions during sampling

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[15] Individual grabs, time-paced (scheduled grabs) composites, storm-event (hydrograph rising limb) flow-paced composites, and continuous flow-paced composites are shown. For a discussion of sample collection methods, see Section 6.2.4 in Progress Report #1.

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(storm-event, baseflow, etc.), the flow rate (more importantly, the discharge volume), or the sampling protocol. The recent elevated results at GS10 (Figure 4-4) are from samples collected during large precipitation events during period the July 30, 1997 through August 6, 1997.

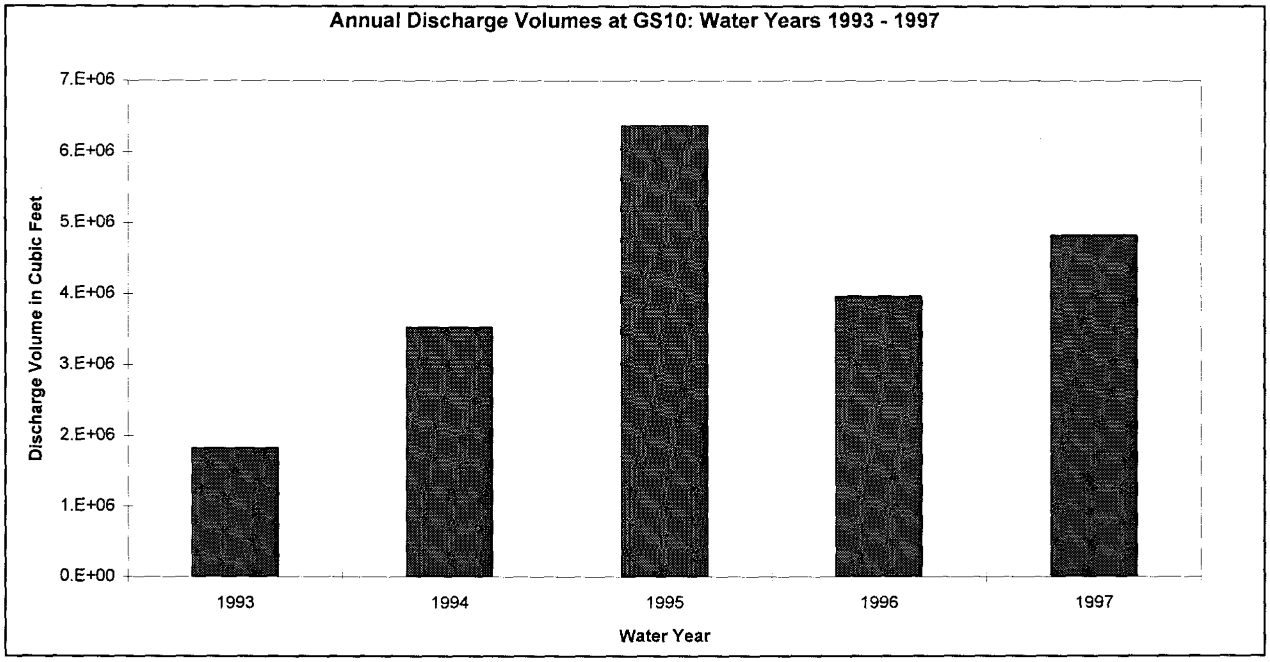


Figure 4-2. Annual Discharge Volumes for GS10.

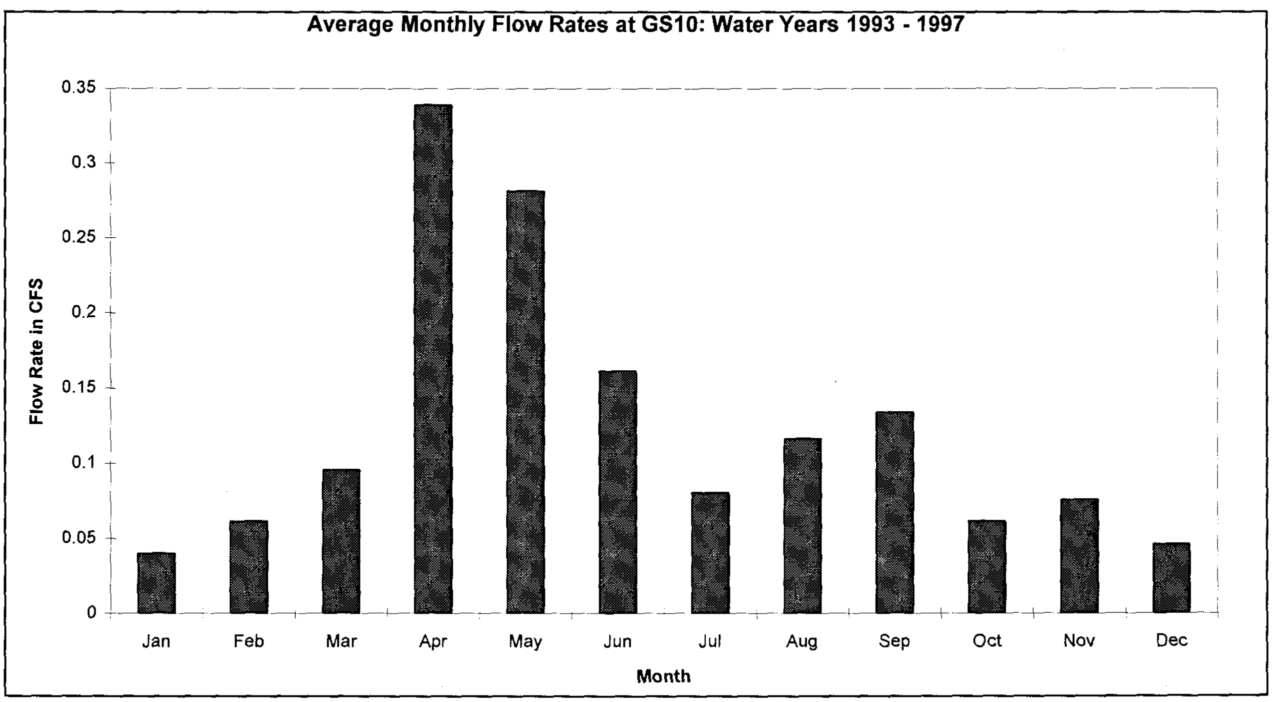


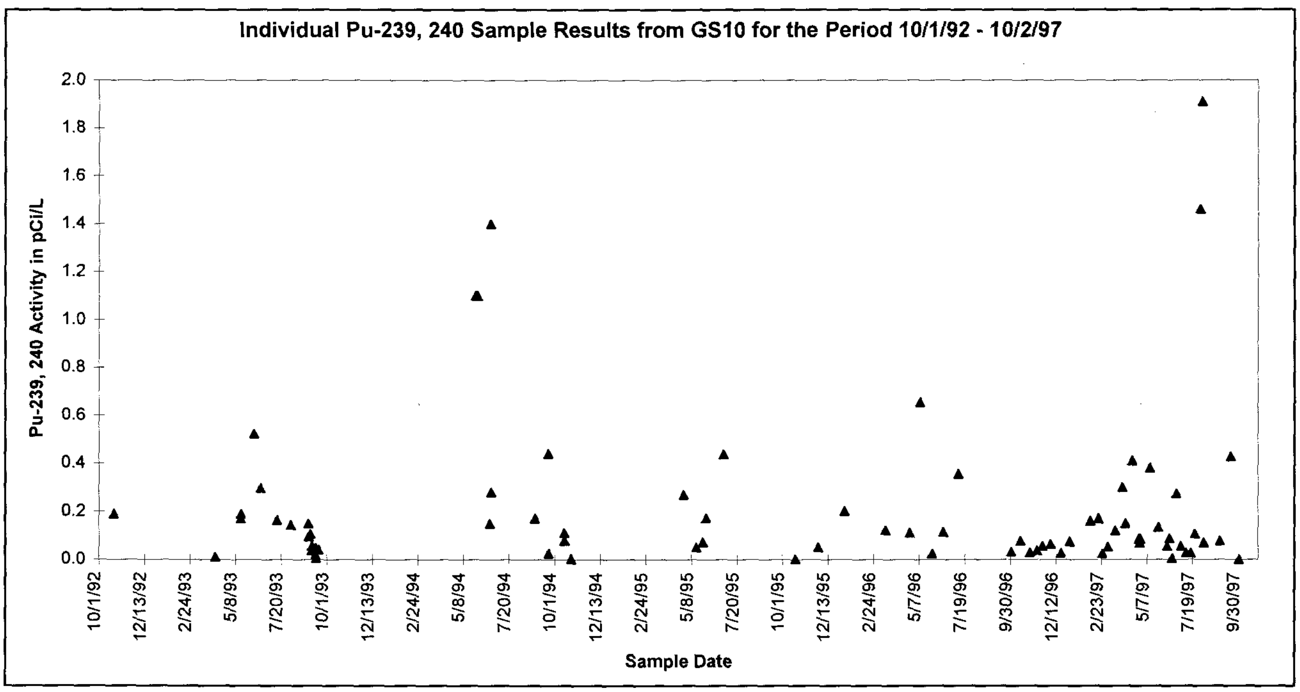
Figure 4-3. Average Monthly Flow Rates at GS10.

Table 4-1. Summary Statistics for Samples from GS10, SW022, GS27, and GS28.

Sampling Location	Number of Samples	Average[b] Activity (pCi/L)	Maximum Result (pCi/L)	Standard Deviation[c] (pCi/L)
GS10				
WY93 - WY96	77	0.219	1.910	0.347
SW022				
WY95 - WY97	22	0.483	6.0	1.272
GS27[a]				
WY95 - WY97	17	19.952	90.0	28.204
WY95 - WY96	10	31.895	90.0	32.053
WY97	7	2.89	6.19	1.667
GS28				
WY95 - WY96	15	0.252	0.852	0.291

[a] Periods are broken out due to GS27 drainage changes in WY96; see details in text discussion below
[b] Arithmetic average
[c] Assumes normal distribution

At gaging station SW022, as shown in Figure 4-5, a sample with an activity of 6.0 pCi/L Pu was collected on August 4, 1997 when the Site received approximately 1.2 inches of precipitation in less than 30 minutes. This event resulted in peak flow rates at GS10 of approximately 50 cfs. This result at SW022 is nearly an order of magnitude larger than previous measurements at SW022.



Results for composite sample collected 9/23/97 have not been returned from lab.

Figure 4-4. Individual Analytical Pu Results for GS10.

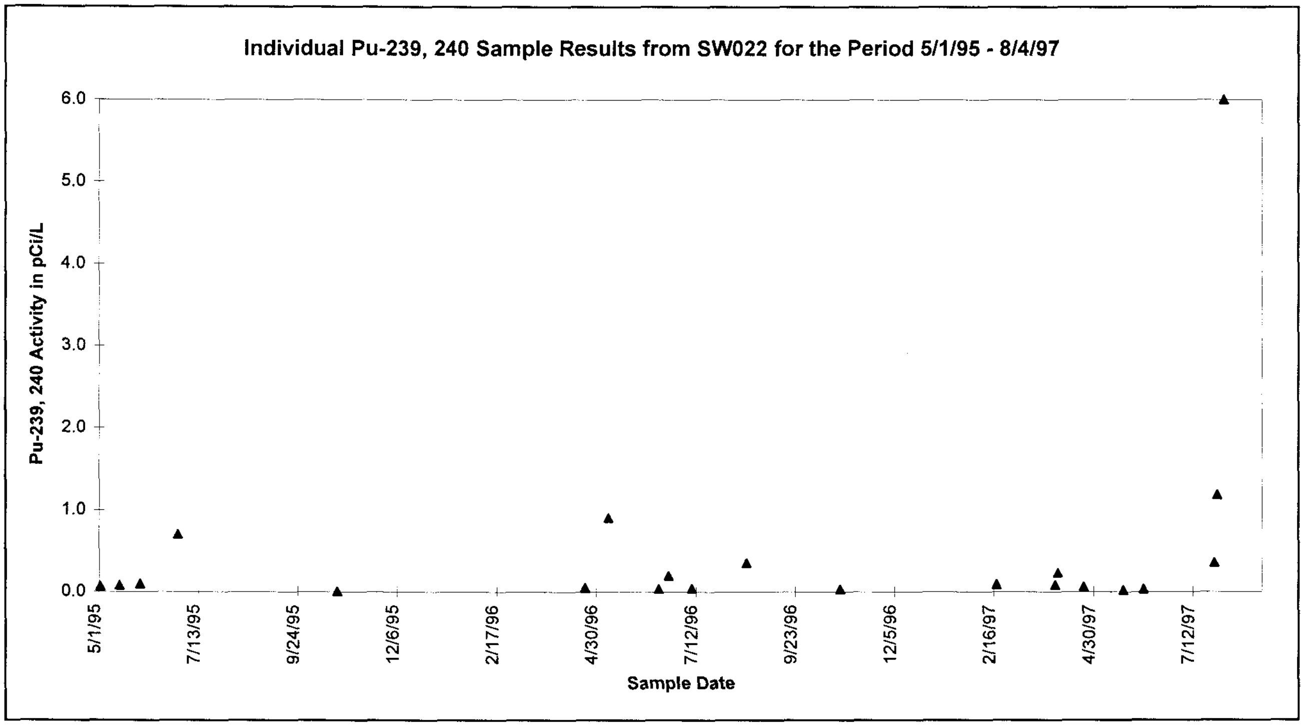


Figure 4-5. Individual Analytical Pu Results for SW022.

The 90.0 pCi/L activity (TSS of 1650 mg/L) at GS27 (Figure 4-6) is the highest activity measured to date by the automated monitoring network for stormwater runoff at the Site. Several other samples were also in the 30 to 75 pCi/L range. GS27 is a Performance Monitoring location originally installed to support the B889 D&D project. Samples were collected before, during, and after the D&D of B889. The drainage basin is approximately 1 acre of pavement and exposed soils. The high activities prompted the Site to initiate an investigation, with the intent being the mitigation of contaminated soils or the removal of a 'hot spot'. Soil activities in the area range from 0.1 to 10 pCi/g. Measured TSS concentrations at this location range from 12.0 to 1650.0 mg/L. If it is assumed that the Pu is associated with soil and surface-water TSS on a strictly mass to mass ratio, runoff with 1650 mg/L of TSS and Pu activity of 90 pCi/L would indicate a soil activity of 56.25 pCi/g in the GS27 drainage. This level of soil activity far exceeds any value measured in the GS27 basin. This indicates soil suspension in runoff may not be uniform, and that the particles most associated with Pu may be preferentially suspended and transported in surface-water runoff.

Consequently, some soil was removed from the drainage ditch immediately upstream of GS27, and exposed soils were treated with a soil stabilizer called Topseal®. Additionally, the D&D and removal of B889 was completed at the end of WY96. A significant change between WY95-WY96 and WY97 sample Pu activities at GS27 can be seen in Table 4-1 and Figure 4-6. The relatively lower activities measured in WY97 are likely a direct result of the completed mitigation projects. Additionally, WY97 TSS values for similar flow magnitudes show a slight decrease. Further discussion on GS27 is contained in Section 4.3.

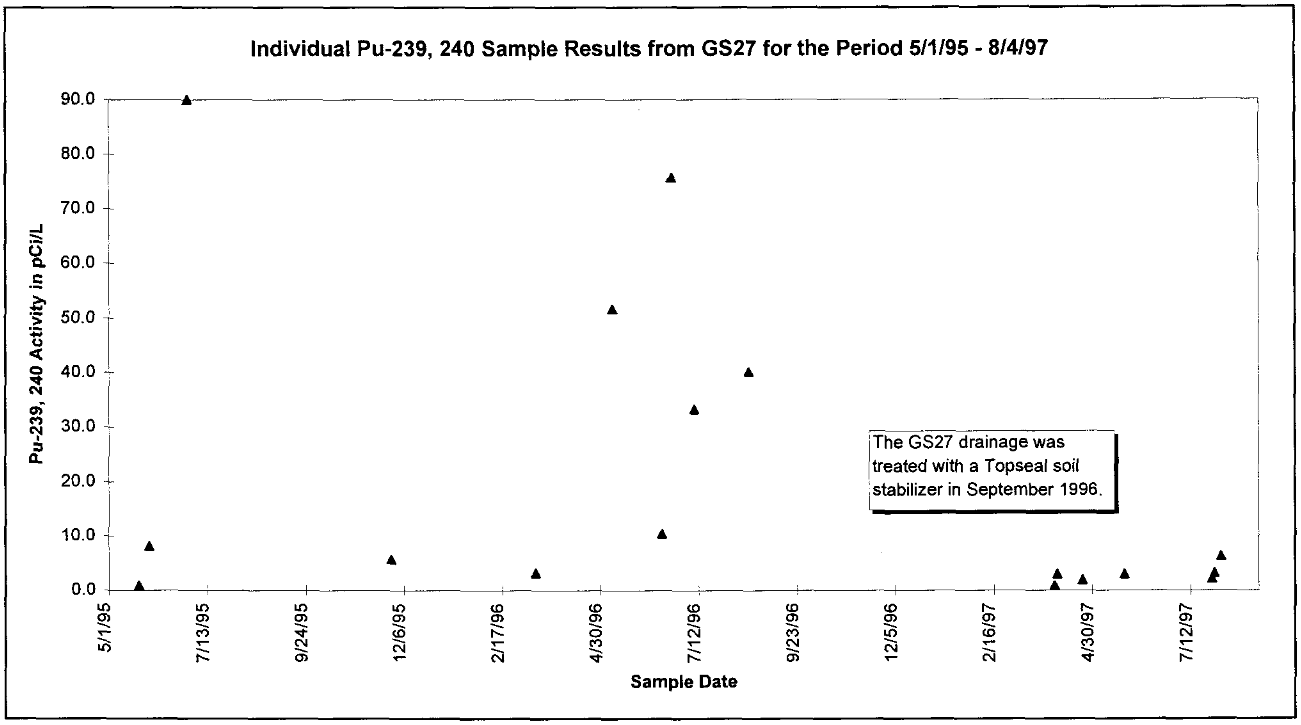


Figure 4-6. Individual Analytical Pu Results for GS27.

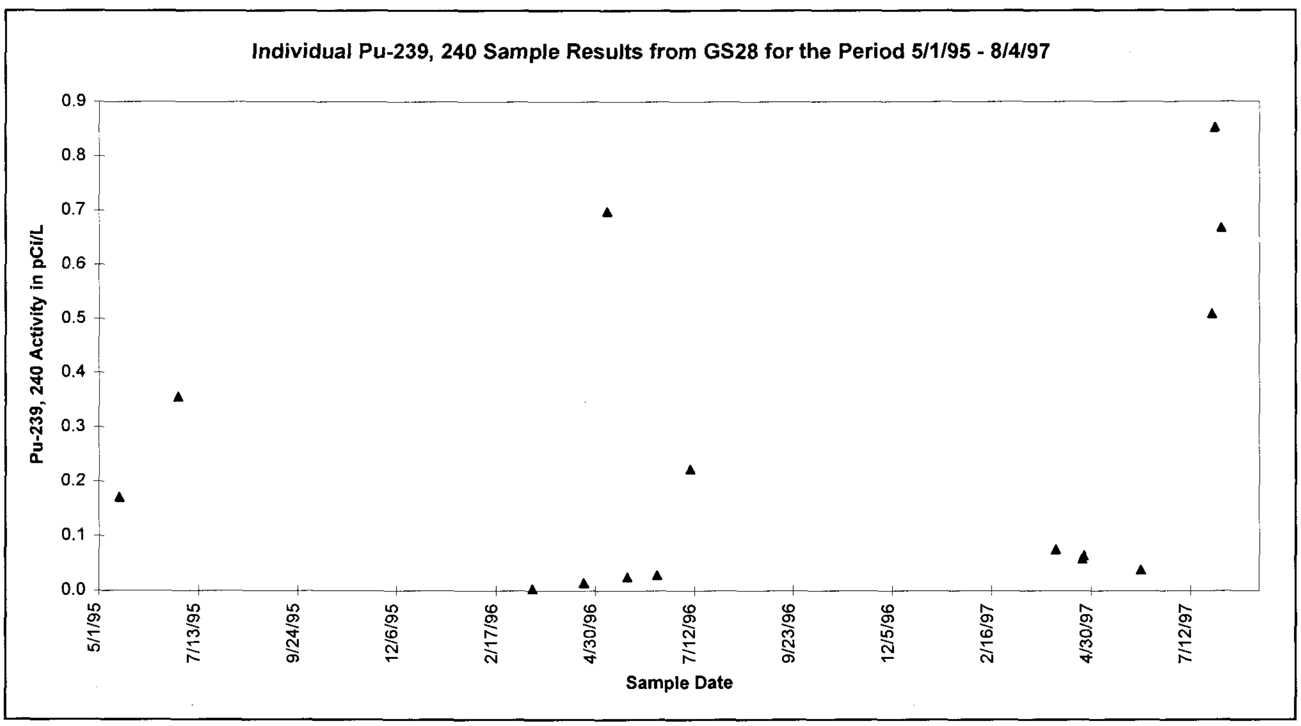


Figure 4-7. Individual Analytical Pu Results for GS28.

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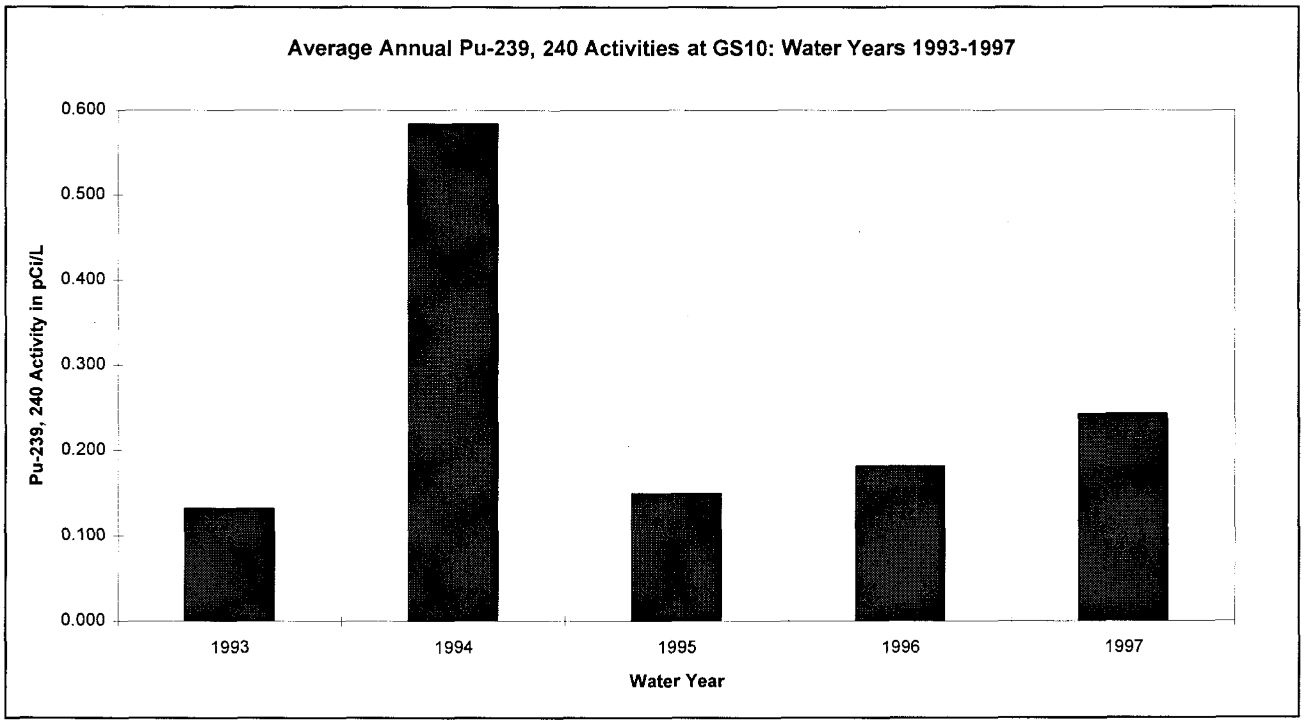
Figure 4-8 shows the average annual activities at GS10 for WY93 - WY97. For WY93 - WY96, arithmetic averages are plotted. However, due to the continuous flow-paced sampling protocols currently in place, the more representative volume-weighted average activity is shown for WY97. This volume-weighted average is calculated in a fashion similar to 30-day averages[4], except that the period is from October 1, 1996 to September 22, 1997.[16] It is important to note that although elevated measurements were made this year, the volume-weighted average is comparable to the activities for other years.

It is generally agreed that Pu tends to form strong associations with particulate matter. If contaminated particles are transported in surface water, then the observed Pu levels could be correlated with the amount of TSS. The data collected at GS10 is a good example (Figure 4-9) of this phenomenon. During high intensity precipitation events, with increased raindrop impact, higher quantities of solids are transported in overland flow. Similarly, higher flow rates in ditches and creeks, generally result in increased TSS values due to higher flow velocity and turbulence. Figure 4-10 shows monthly arithmetic average activities which increase for months with higher rainfall and flow rates which are shown on Figure 4-3. The high activities for the month of August are likely a result the recent intense monsoon-related precipitation during July 30, 1997 through August 6, 1997.



Volume-weighted WY97 average is plotted.

Figure 4-8. Average Annual Pu Activities for GS10.

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[16] Each carboy has a load in pCi calculated from the activity and the associated creek discharge volume. The total load in pCi for all samples is then divided by the total creek discharge volume to give the volume-weighted activity in pCi/L.

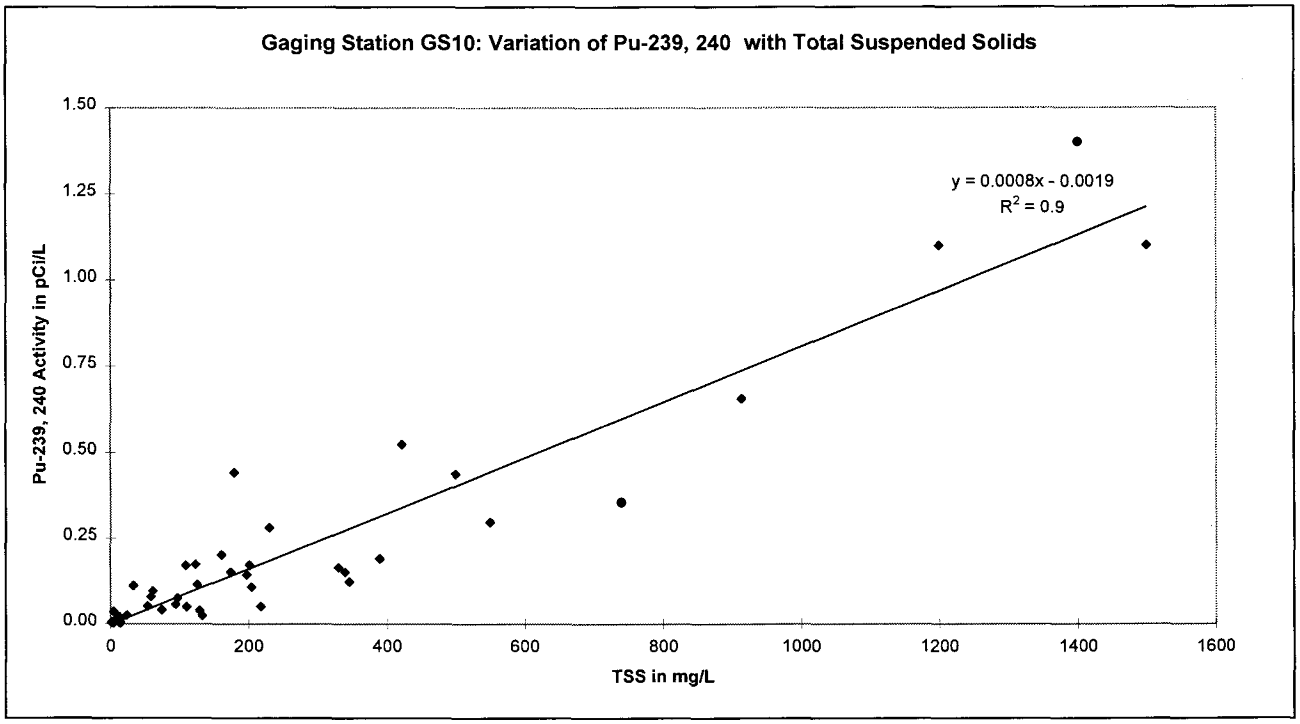
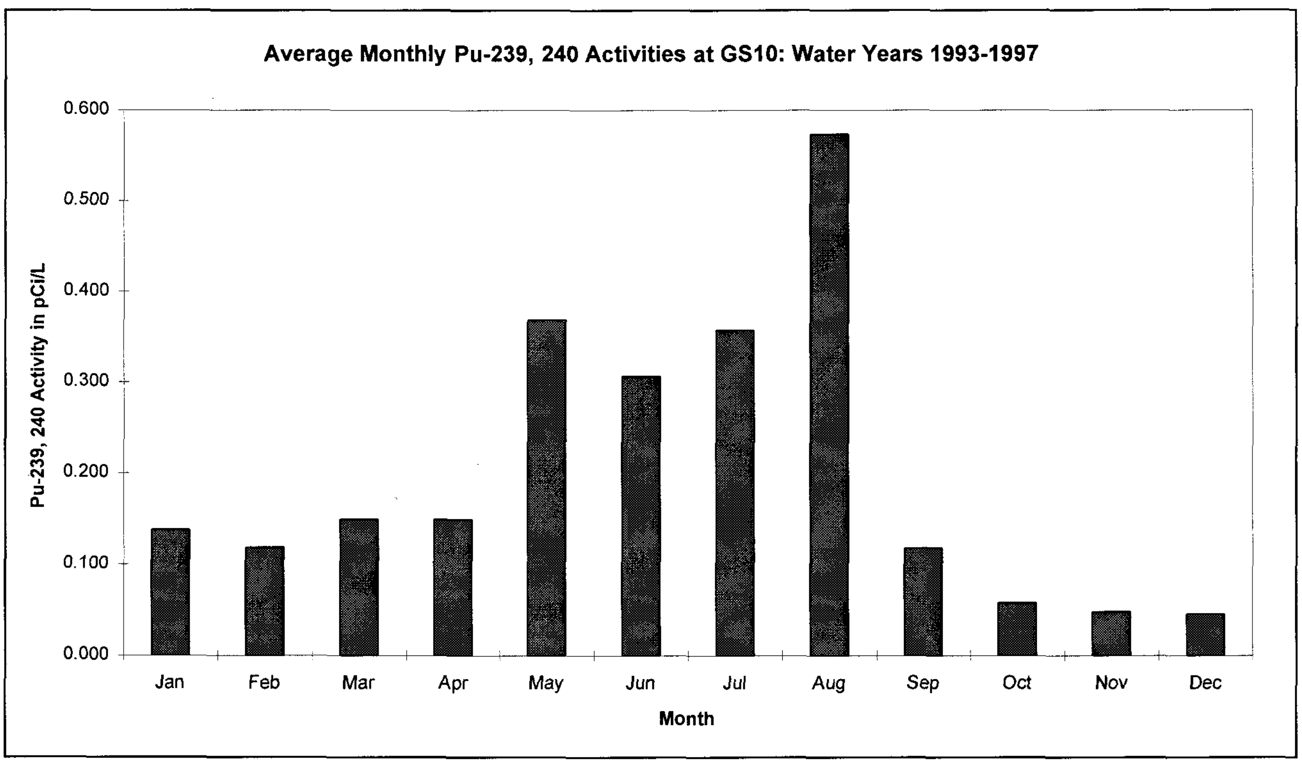


Figure 4-9. Variation of Pu with Total Suspended Solids at GS10.



All averages are arithmetic.

Figure 4-10. Average Monthly Pu Activities in Walnut Creek.

4.2.2. Loading Analysis

WY93 - WY97 Monitoring Data

Annual loads for GS10 in micrograms are plotted in Figure 4-11. For WY93 - WY96, the arithmetic average activity is multiplied by the associated total annual discharge volume, then converted to micrograms. For WY97, the activity for each flow-paced composite is multiplied by the associated discharge volume, then converted to micrograms and totaled.

Loading for various sub-drainages tributary to GS10 was estimated by multiplying the arithmetic average Pu activity at the gaging stations (which define the sub-drainages) by the corresponding average annual discharge for each gage. Figure 4-12 shows that the small GS27 sub-basin may contribute approximately 36% of the Pu load reaching SW022. However, other basins contributing to the Central Avenue Ditch, including the 903 Pad, contribute approximately 62% of the Pu load. This gain indicates that Pu entered Central Avenue Ditch from areas other than those monitored by GS27 and GS28.

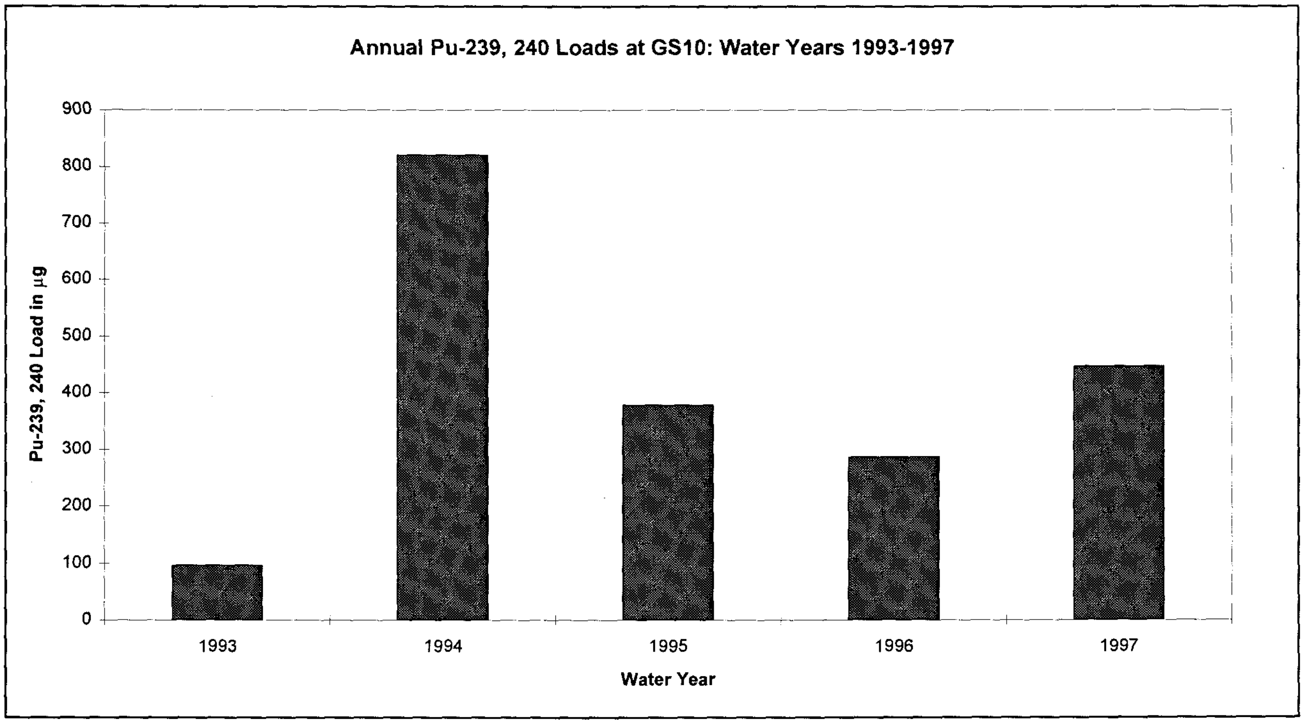


Figure 4-11. Annual Pu Loads in Walnut Creek.

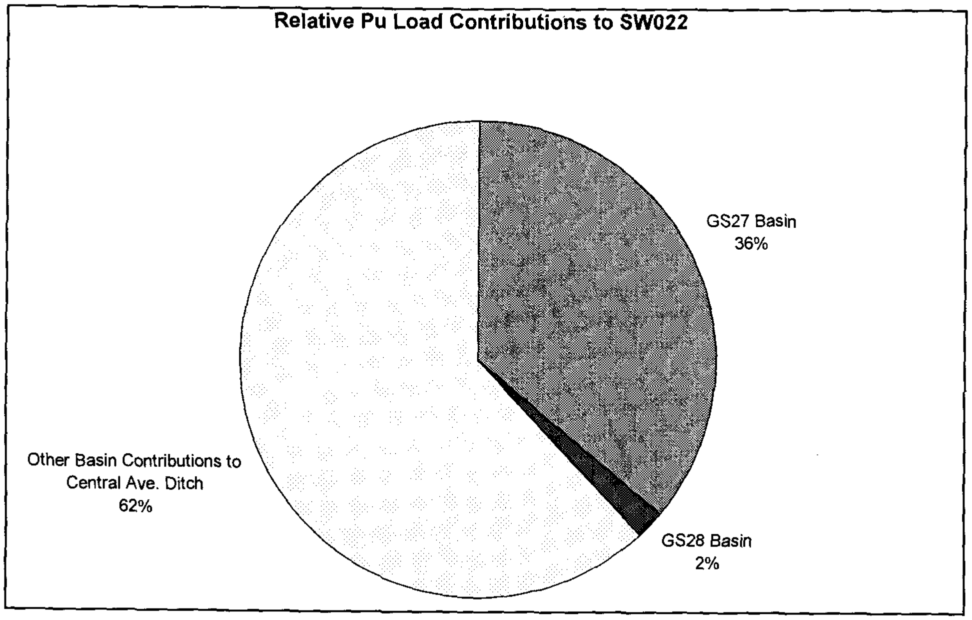


Figure 4-12. Relative Sub-Basin Loads to SW022: WY93-WY97.

Figure 4-13 shows that the small GS27 sub-basin may contribute approximately 26% of the Pu load reaching GS10. However, watershed improvements have significantly reduced the contribution from this sub-basin, as discussed below in the analysis solely for WY97 data. Figure 4-13 also indicates that sub-basins along the south side of the Protected Area (PA), which flow directly to GS10, contribute approximately 29% of the Pu load. These loading distributions indicate that there are multiple Pu sources contributing to GS10.

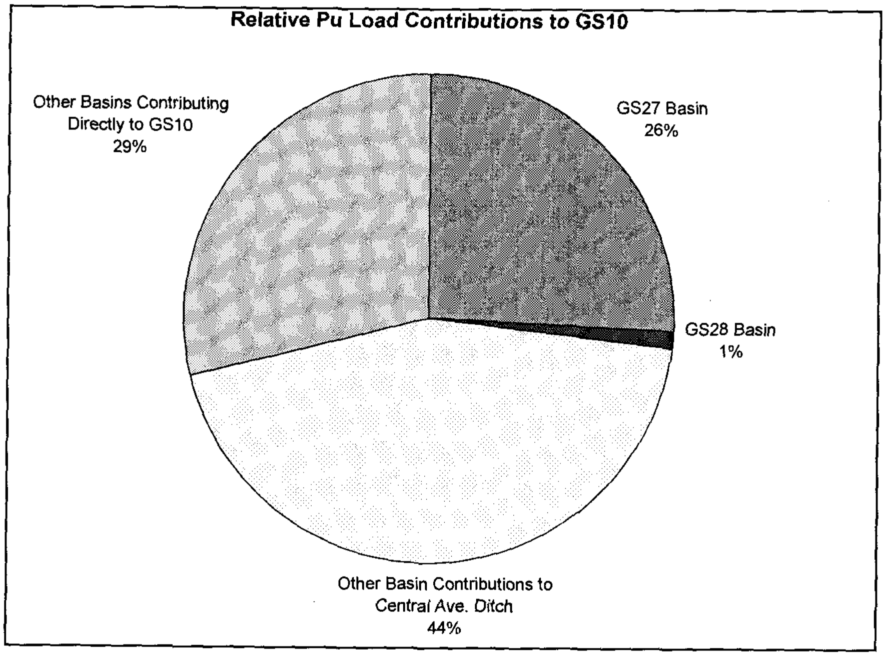


Figure 4-13. Relative Sub-Basin Loads to GS10: WY93-WY97.

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WY97 Continuous Flow-Paced Monitoring Data

Figure 4-14 shows volume-weighted average monthly activities for continuous flow-paced samples collected in WY97 at GS10. Analytical results are available through September 22, 1997. The upward trend is likely due to seasonal hydrologic (more intense runoff), chemical, and biological variations which may result in the increased mobility of Pu.

Detail for each continuous flow-paced composite sample for WY97 at GS10 is presented in Table 4-2. Elevated samples are indicated in bold. Detail for each flow-paced storm-event composite sample from SW022, GS27, and GS28 is presented in Table 4-3. It is important to note the highly variable activity for the samples. It is apparent that the variability of surface-water activity and the transport mechanisms for Pu are not fully understood.

Prior to WY97, all locations collected flow-paced storm-event samples. During WY97, continuous flow-paced samples were collected at GS10, while flow-paced storm-event samples were collected at SW022, GS27, and GS28. When comparing the GS10 protocols, the WY97 volume-weighted average is 0.242 pCi/L Pu, while the WY93-WY96 arithmetic average of storm-event samples was 0.237 pCi/L Pu. Assuming that the total drainage has not changed significantly, this implies that arithmetic average storm-event samples can be compared directly to volume-weighted averages with reasonable accuracy for GS10. Loading analysis for various sub-drainages tributary to GS10 was estimated by multiplying the arithmetic average Pu activity at the gaging stations (SW022, GS27, and GS28 which define the sub-drainages) by the corresponding average annual discharge for each gage. For GS10, the activity for each flow-paced composite is multiplied by the associated discharge volume, then converted to micrograms and totaled (Table 4-2). Figure 4-15 shows that the small GS27 sub-basin contributed approximately 3% of the Pu load reaching SW022, a significant decrease from previous years after watershed improvements. However, other basins contributing to the Central Avenue Ditch, including the 903 Pad, contribute approximately 96% of the Pu load. This gain indicates that Pu entered Central Avenue Ditch from areas other than those monitored by GS27 and GS28.

Table 4-2. Detail for WY97 Continuous Flow-Paced Composite Samples at GS10.

Sample Start Time	Sample End Time	Discharge Volume During Sample (cubic feet)	Pu-239, 240 Activity (pCi/L)	Pu-239, 240 Load (micrograms)
10/1/96 11:24	10/16/96 13:51	68375 [a]	0.032	0.87
10/16/96 13:51	10/31/96 9:13	93846	0.077	2.88
10/31/96 9:13	11/11/96 23:57	49095	0.0295	0.58
11/11/96 23:57	11/20/96 15:13	74221	0.037	1.10
11/20/96 15:13	12/3/96 15:52	79418	0.057	1.81
12/3/96 15:52	12/20/96 15:15	67745	0.064	1.73
12/20/96 15:15	1/3/97 14:25	61756	0.027	0.67
1/3/97 14:25	2/5/97 16:37	152467	0.074	4.50
2/5/97 16:37	**2/18/97 14:37**	**63597**	**0.16**	**4.06**
2/18/97 14:37	**2/24/97 15:51**	**84912**	**0.17**	**5.76**
2/24/97 15:51	3/5/97 14:51	87008	0.025	0.87
3/5/97 14:51	3/17/97 11:06	71098	0.054	1.53
3/17/97 11:06	3/28/97 9:13	86086	0.12	4.12
3/28/97 9:13	**4/2/97 16:10**	**38549**	**0.3**	**4.61**
4/2/97 16:10	**4/11/97 13:56**	**182496**	**0.15**	**10.92**
4/11/97 13:56	**4/24/97 8:56**	**328065**	**0.41**	**53.65**
4/24/97 8:56	4/25/97 12:59	213488	0.086	7.32
4/25/97 12:59	4/26/97 17:02	321887	0.07	8.99
4/26/97 17:02	5/12/97 16:01	360457	0.086	12.37
5/12/97 16:01	**5/25/97 15:48**	**158561**	**0.38**	**24.03**
5/25/97 15:48	6/8/97 13:53	221434	0.134	11.84
6/8/97 13:53	6/12/97 10:05	42200	0.056	0.94
6/12/97 10:05	6/16/97 8:06	61625	0.088	2.16
6/16/97 8:06	6/23/97 7:35	47979	0.005	0.10
6/23/97 7:35	**6/30/97 13:24**	**48441**	**0.274**	**5.29**
6/30/97 13:24	7/8/97 7:49	46557	0.056	1.04
7/8/97 7:49	7/16/97 15:24	56555	0.028	0.63
7/16/97 15:24	7/23/97 15:41	55268	0.026	0.57
7/23/97 15:41	7/31/97 9:09	263898	0.107	11.26
7/31/97 9:09	**8/4/97 17:25**	**158668**	**1.46**	**92.40**
8/4/97 17:25	**8/6/97 7:55**	**300046**	**1.91**	**228.60**
8/6/97 7:55	9/1/97 9:14	457693	0.07	12.78
9/1/97 9:14	9/18/97 10:27	101433	0.077	3.12
9/18/97 10:27	**9/23/97 2:33**	**230406**	**0.427**	**39.24**

Elevated samples above the action level are indicated in bold.

[a] Discharge volume calculated from 10/1/96 0:00 for loading purposes.

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Table 4-3. Detail for WY97 Flow-Paced Storm-Event Composite Samples at SW022, GS27, and GS28.

Location	Sample Date	Pu-239, 240 Activity (pCi/L)
SW022	10/26/96	0.029
	2/18/97	0.087
	4/2/97	0.082
	4/4/97	0.230
	4/23/97	0.060
	5/22/97	0.019
	6/6/97	0.030
	7/28/97	0.357
	7/30/97	1.180
	8/4/97	6.000
GS27		
	4/2/97	0.870
	4/4/97	3.000
	4/23/97	1.900
	5/24/97	3.000
	7/28/97	2.100
	7/30/97	3.170
	8/4/97	6.190
GS28		
	4/4/97	0.075
	4/24/97	0.058
	4/25/97	0.064
	6/6/97	0.038
	7/28/97	0.509
	7/30/97	0.852
	8/4/97	0.667

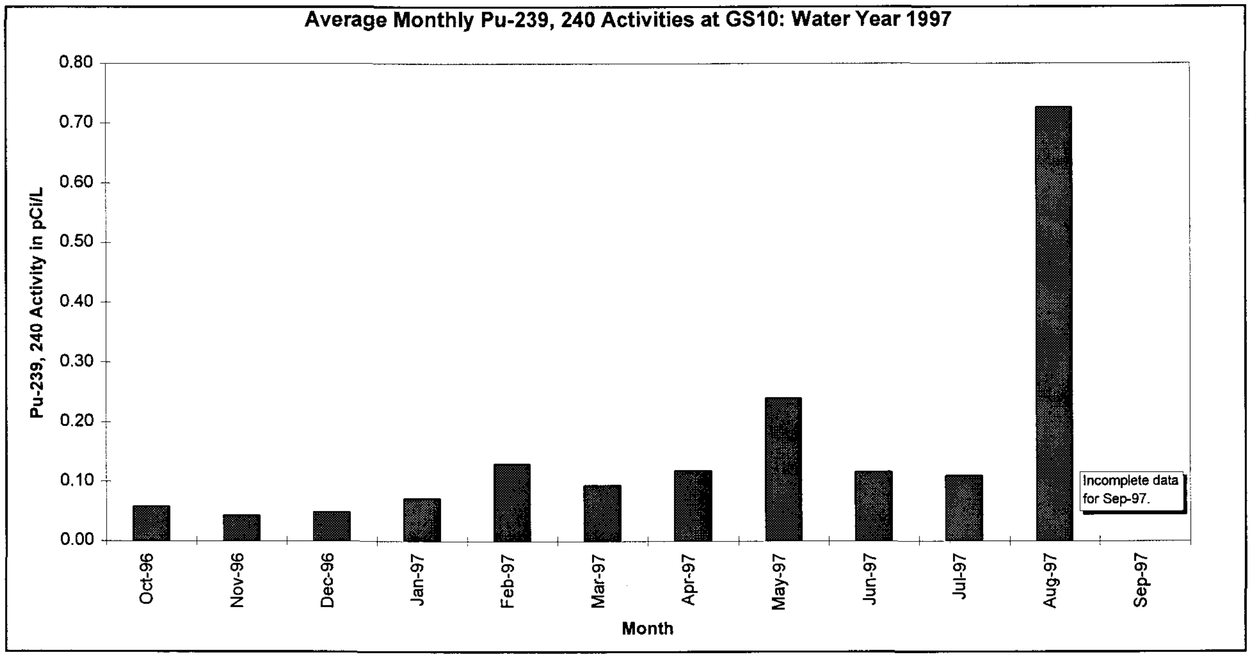

Figure 4-14. Average Monthly Pu Activities for WY97 at GS10.

Figure 4-16 also indicates that sub-basins along the south side of the PA, which flow directly to GS10, contribute approximately 31% of the Pu load. Figure 4-16 also indicates that the southern IA feeding the Central Avenue Ditch is a significant source, indicating the need for additional Source Location monitoring stations (see Section 9.3.4 and Figure 9-1). These loading distributions also indicate that there are multiple Pu sources contributing to GS10.

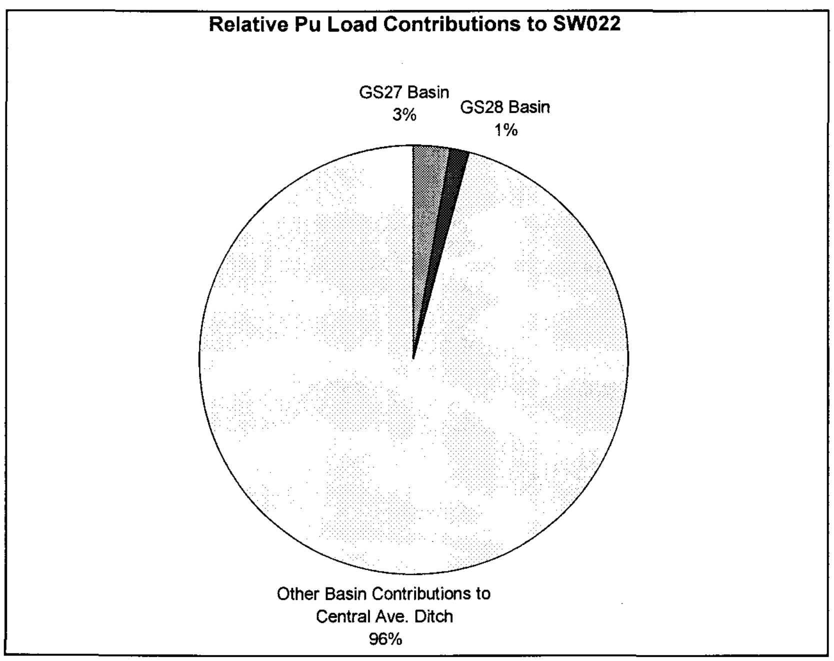

Figure 4-15. Relative Sub-Basin Loads to SW022: WY97.

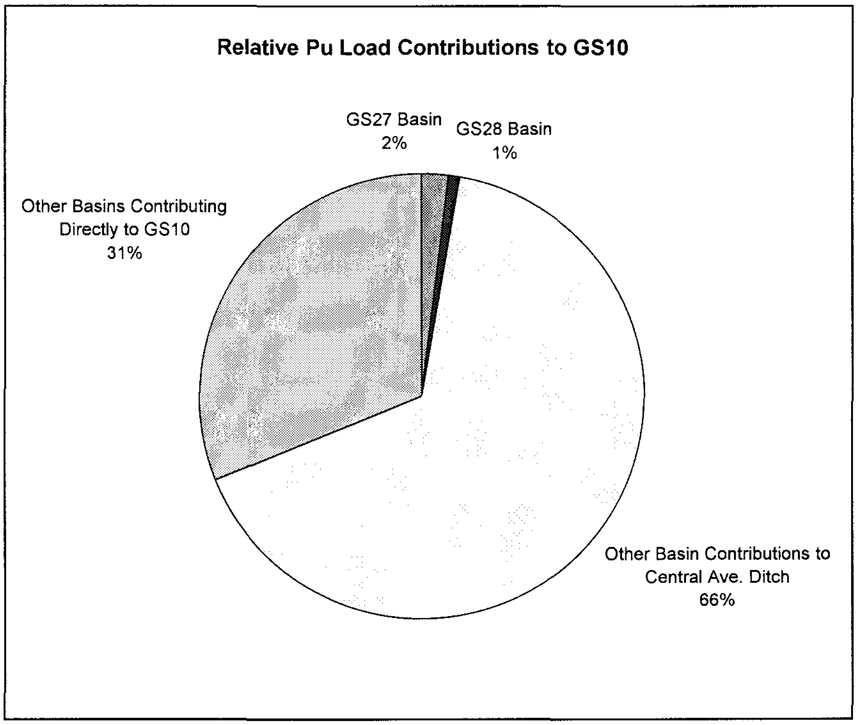

Figure 4-16. Relative Sub-Basin Loads to GS10: WY97.

4.2.3. Data Correlations

Flow Rates

As stated previously, Pu tends to form strong associations with particulate matter (as shown in Figure 4-17 for GS10). If these particles are transported in surface water, then so is Pu. During high intensity precipitation events, with increased raindrop impact, higher quantities of solids are transported in overland flow. Similarly, higher flow rates in ditches and creeks, generally result in increased TSS values due to higher flow velocity and turbulence.

Figure 4-18 shows the variation of Pu activity with flow for GS10. The activity plotted is the analytical result for the sample; the flow is the average of the flow rates during each composite grab. An upward trend generally indicates the increased movement of Pu during higher flow rates. This can occur when the source is widespread (movement through overland flow and raindrop impact), or when the source exists in the streambed itself (movement through increased scouring). These are the mechanisms commonly seen at other Site monitoring locations. A downward trend may indicate that groundwater may be a source. For example, during low flow rates a contaminated groundwater source could make up the a larger proportion of the flow, and result in higher activities. During runoff when relatively cleaner water enters the creek, the groundwater source would be diluted, resulting in lower activities. Figure 4-18 indicates an upward trend in activity with higher flow rates.

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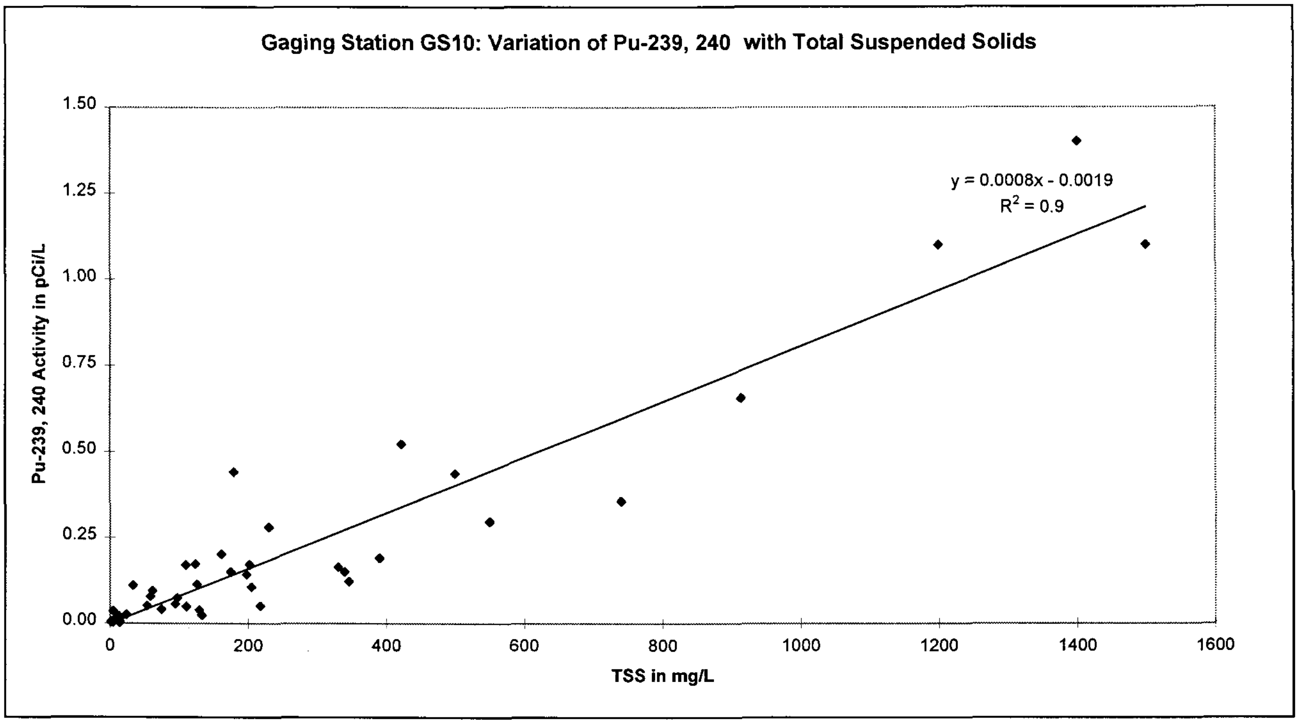

Figure 4-17. Variation of Pu with Total Suspended Solids at GS10.

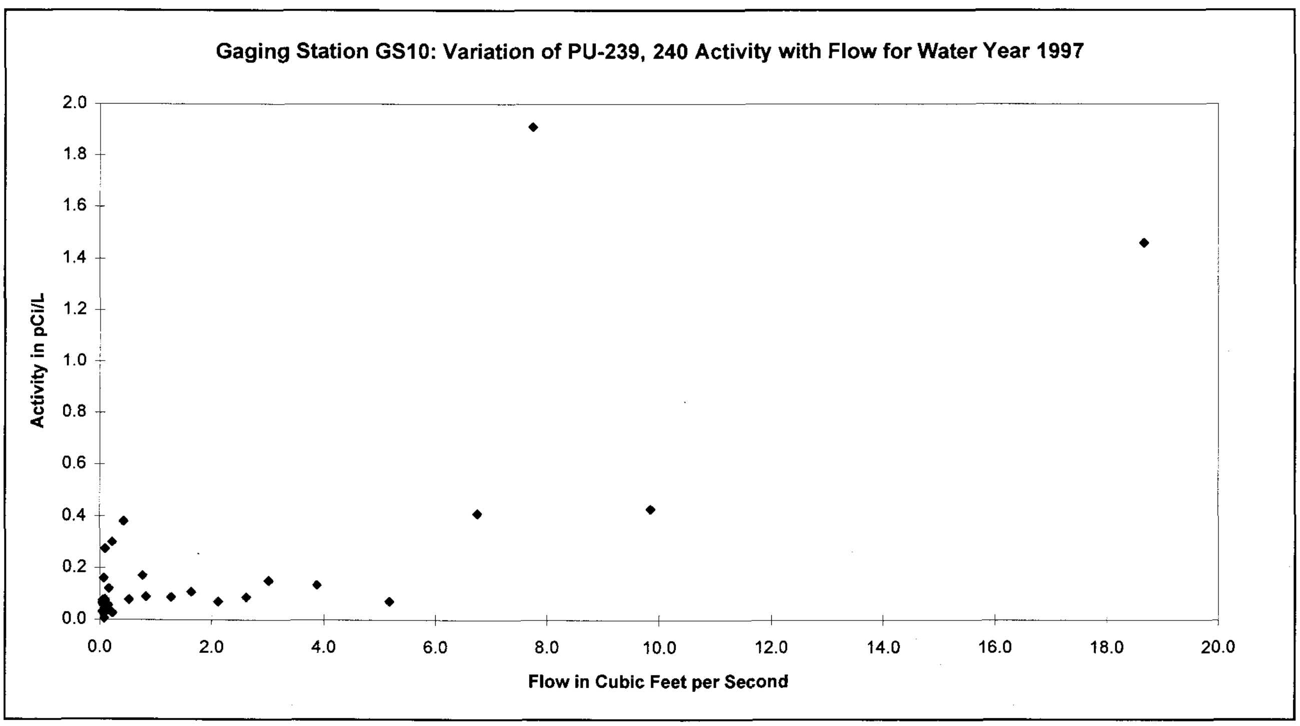

Figure 4-18. Variation of Pu Activity with Flow Rate at GS10: WY97.

Precipitation

If it is assumed that a source exists in the GS10 drainage, then increased precipitation (and flow rates) or increased precipitation intensity (raindrop scouring) could result in increased transport to GS10. Figure 4-18 indicates that Pu activities generally increase with increasing flow rates. Since South Walnut Creek is basically an ephemeral stream with little baseflow and a hydrograph punctuated by high runoff from impervious areas during precipitation events, the flow rate is directly influenced by precipitation. Therefore, if it is assumed that activity is related to flow and flow is related to precipitation, then activity may also be related to precipitation.

A detailed view of the composite sample periods for the elevated measurements at GS10 is given in Figure 4-19 through Figure 4-27. Due to the flow-paced sampling protocols, it can be seen that most of the grabs for the elevated samples were collected during periods of higher flows due to direct stormwater runoff. Missed grabs were caused by frozen sampling equipment.

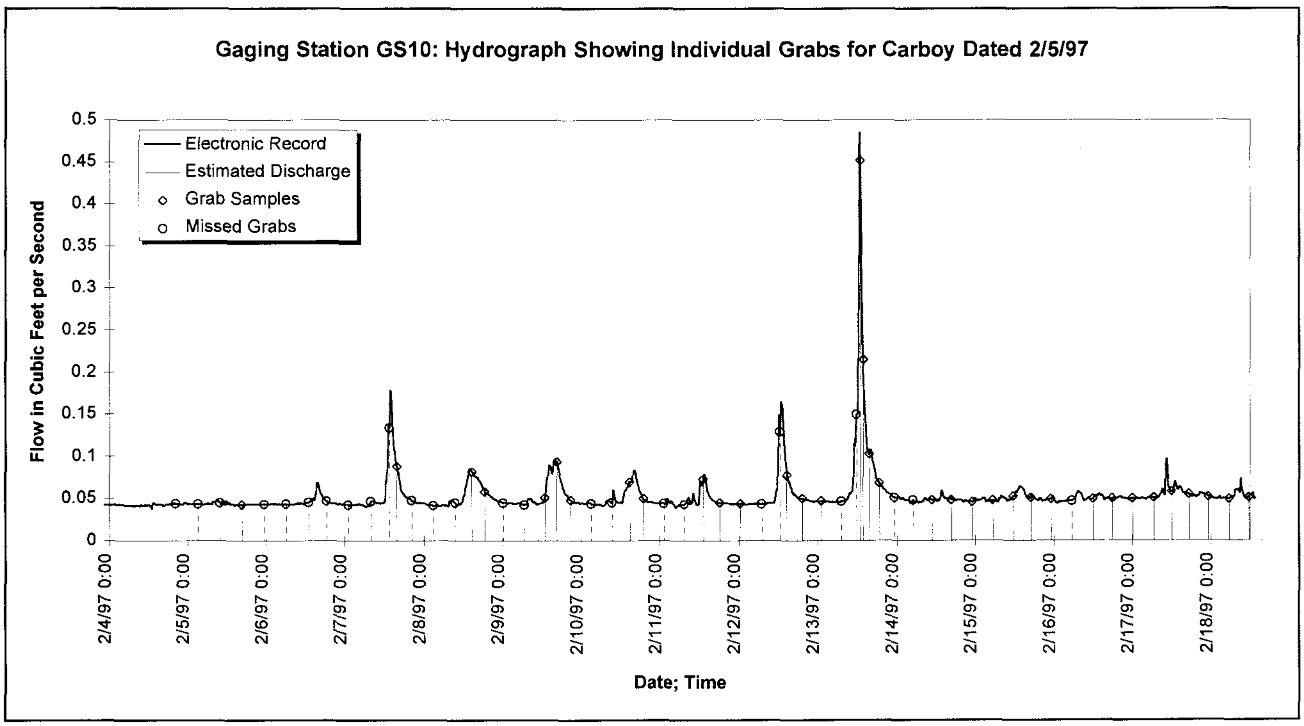

Figure 4-19. GS10 Hydrograph and Grab Samples for Composite Sample Dated February 5, 1997.

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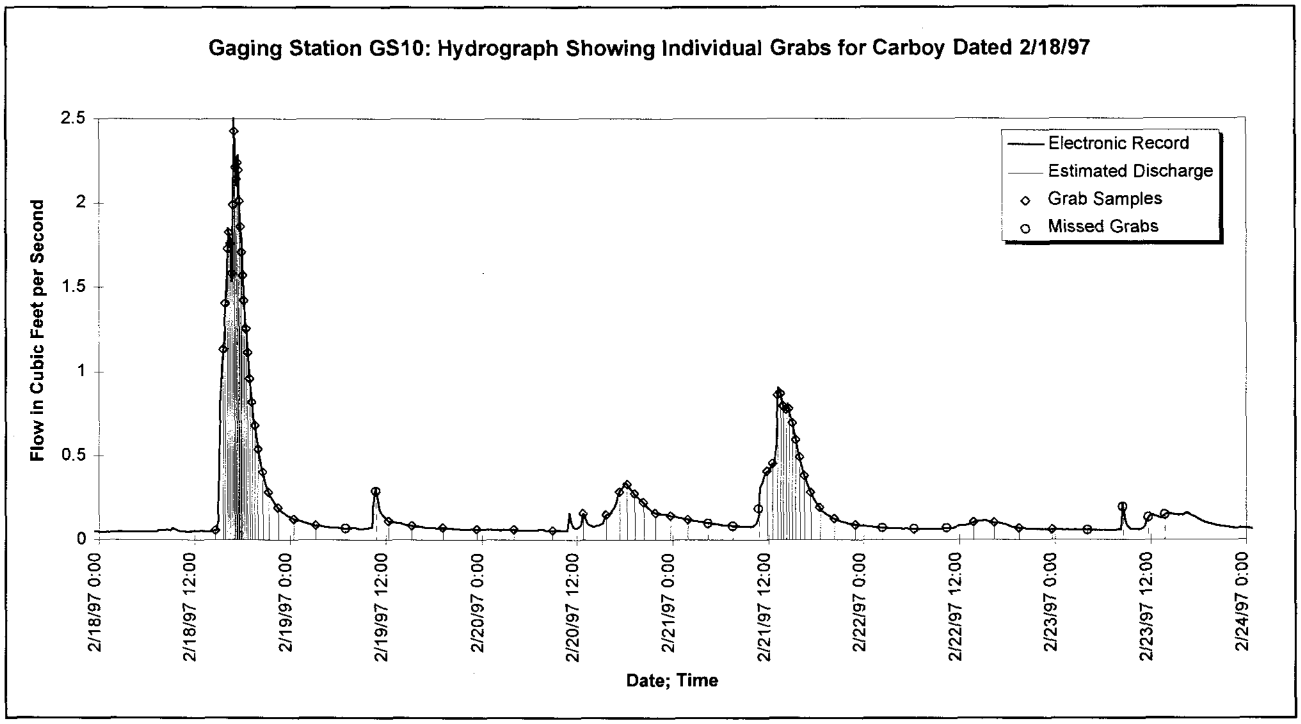

Figure 4-20. GS10 Hydrograph and Grab Samples for Composite Sample Dated February 18, 1997.

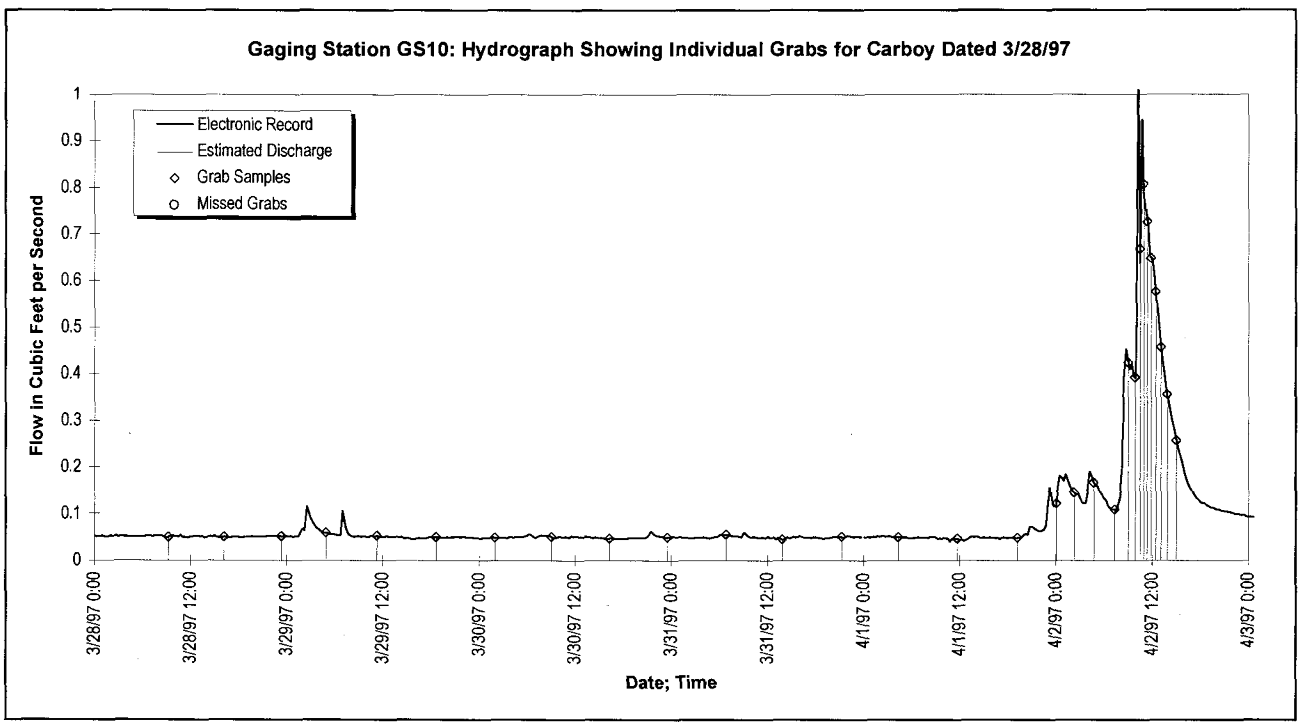

Figure 4-21. GS10 Hydrograph and Grab Samples for Composite Sample Dated March 28, 1997.

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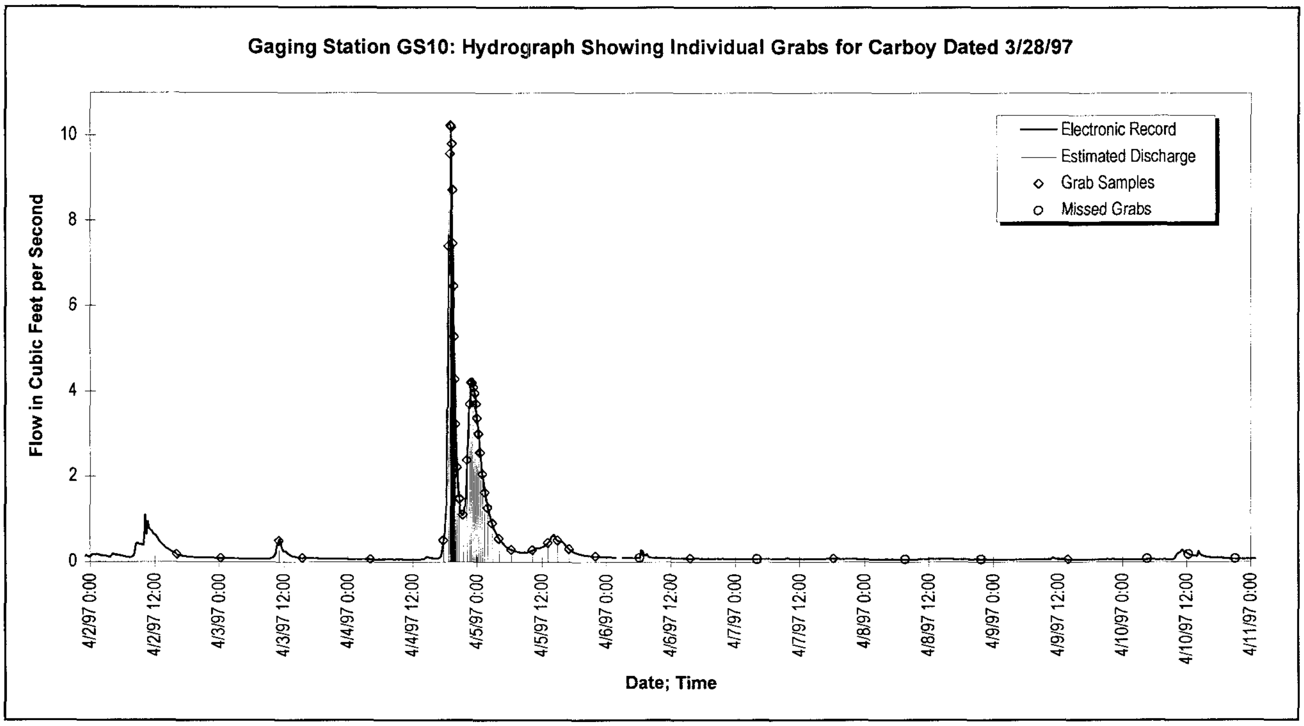

Figure 4-22. GS10 Hydrograph and Grab Samples for Composite Sample Dated April 2, 1997.

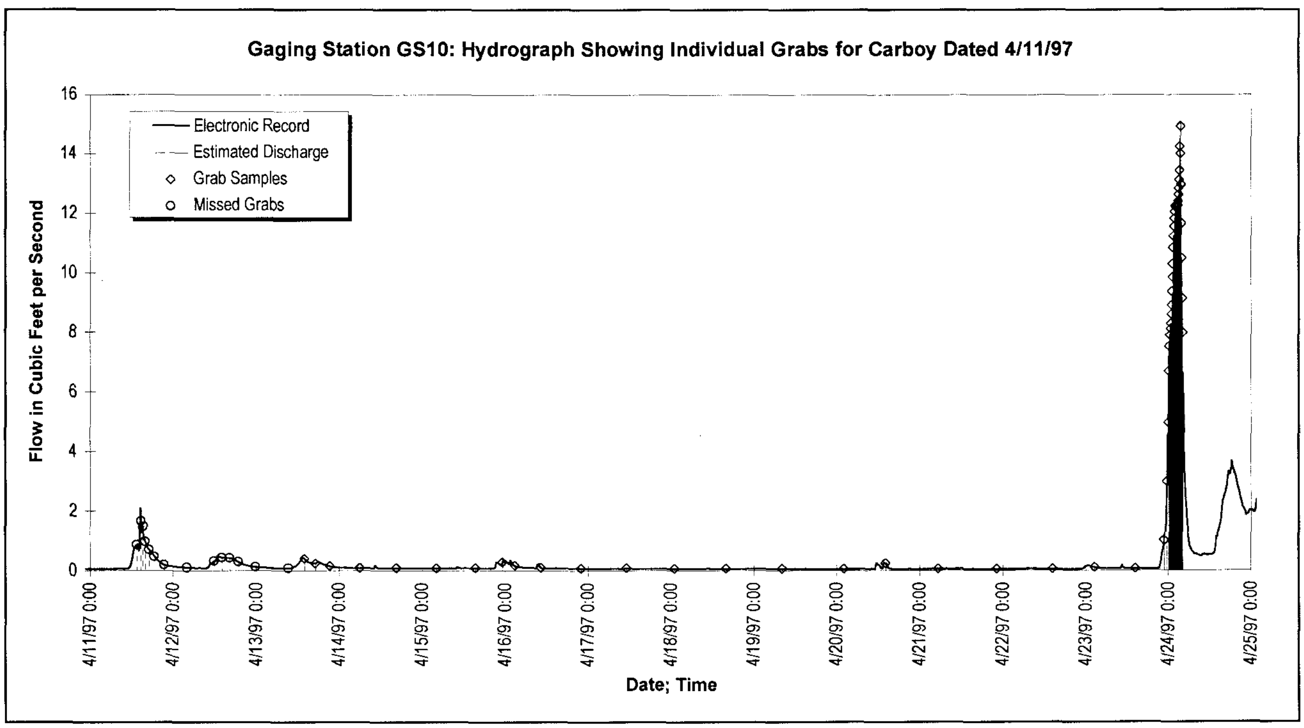

Figure 4-23. GS10 Hydrograph and Grab Samples for Composite Sample Dated April 11, 1997.

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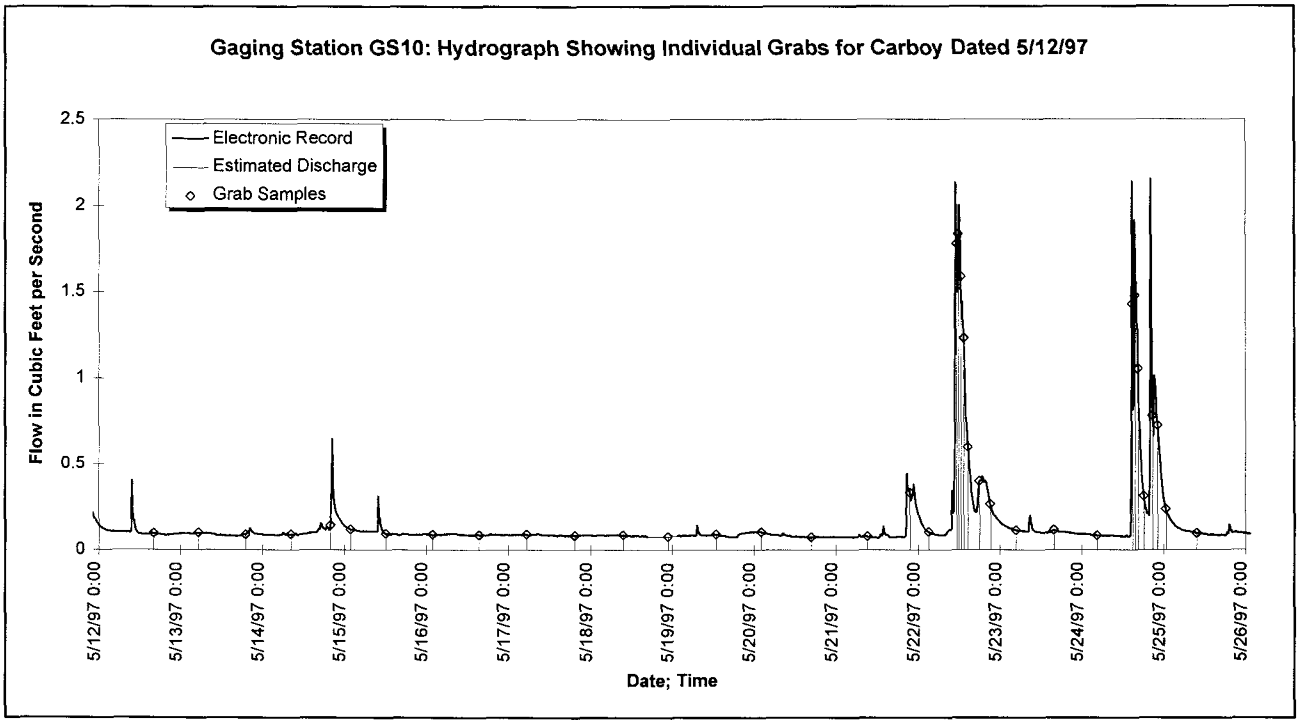

Figure 4-24. GS10 Hydrograph and Grab Samples for Composite Sample Dated May 12, 1997.

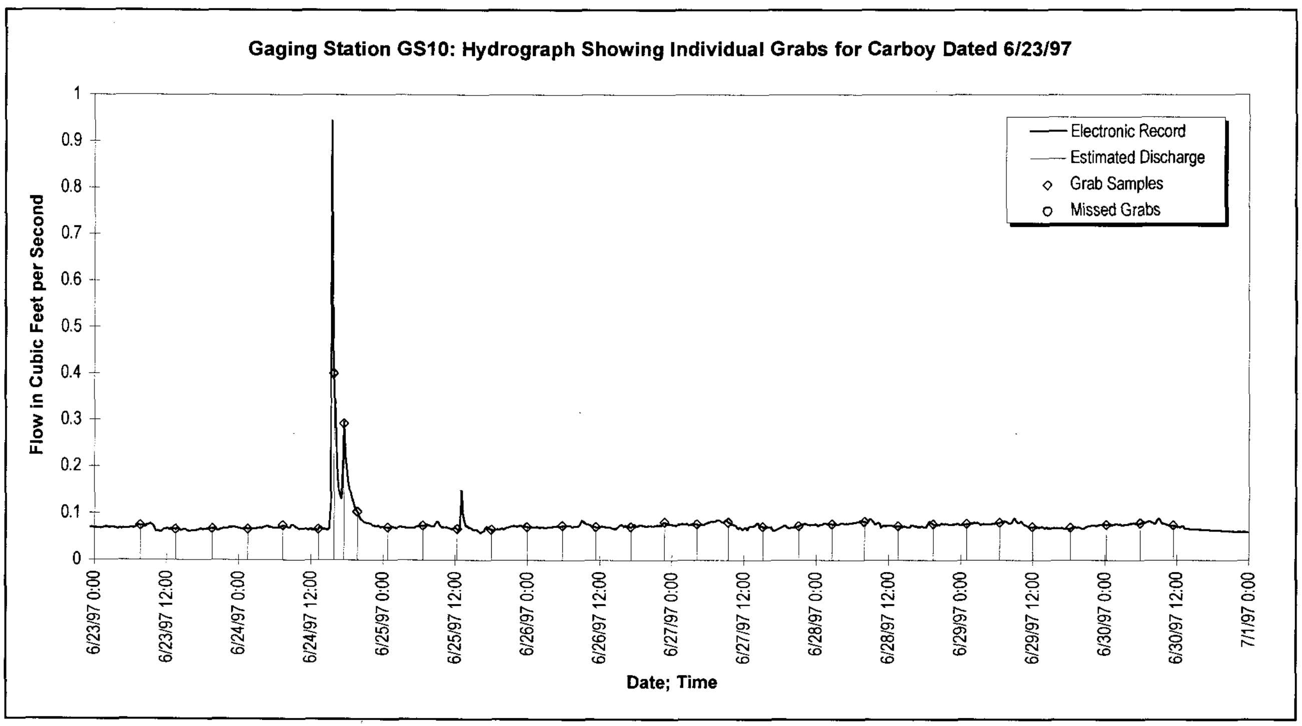

Figure 4-25. GS10 Hydrograph and Grab Samples for Composite Sample Dated June 23, 1997.

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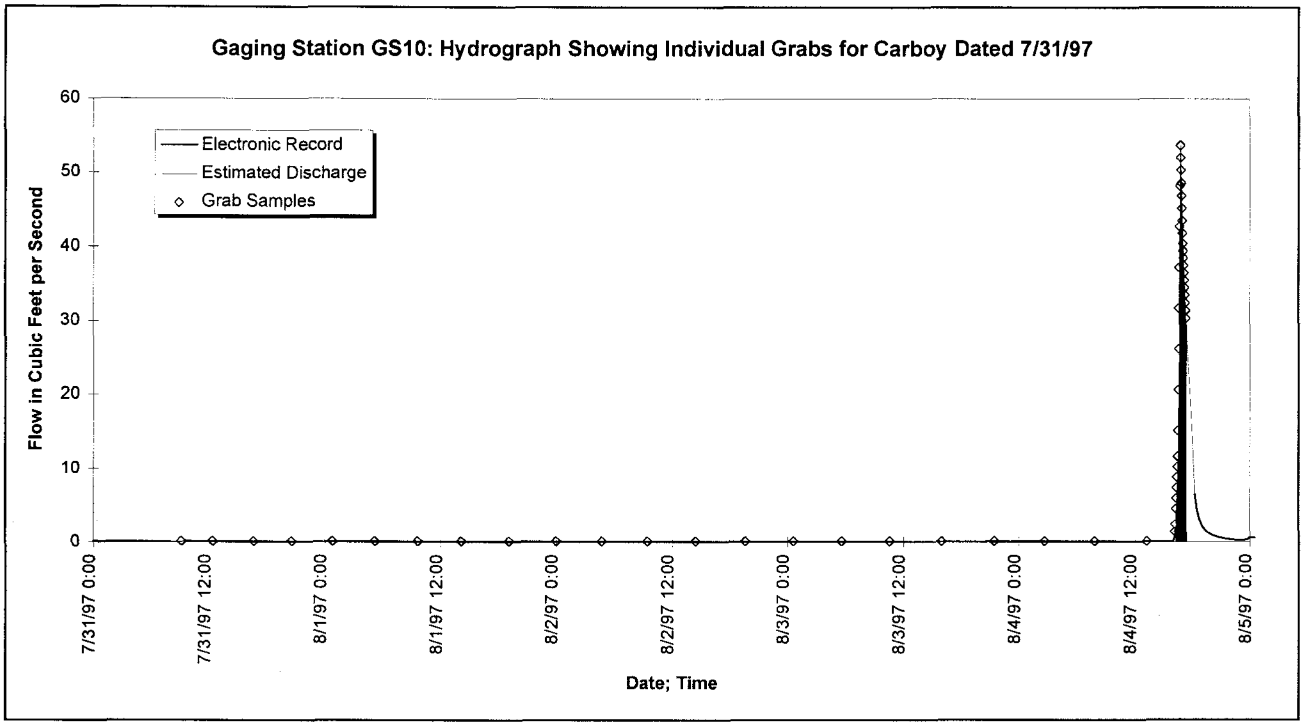

Figure 4-26. GS10 Hydrograph and Grab Samples for Composite Sample Dated July 31, 1997.

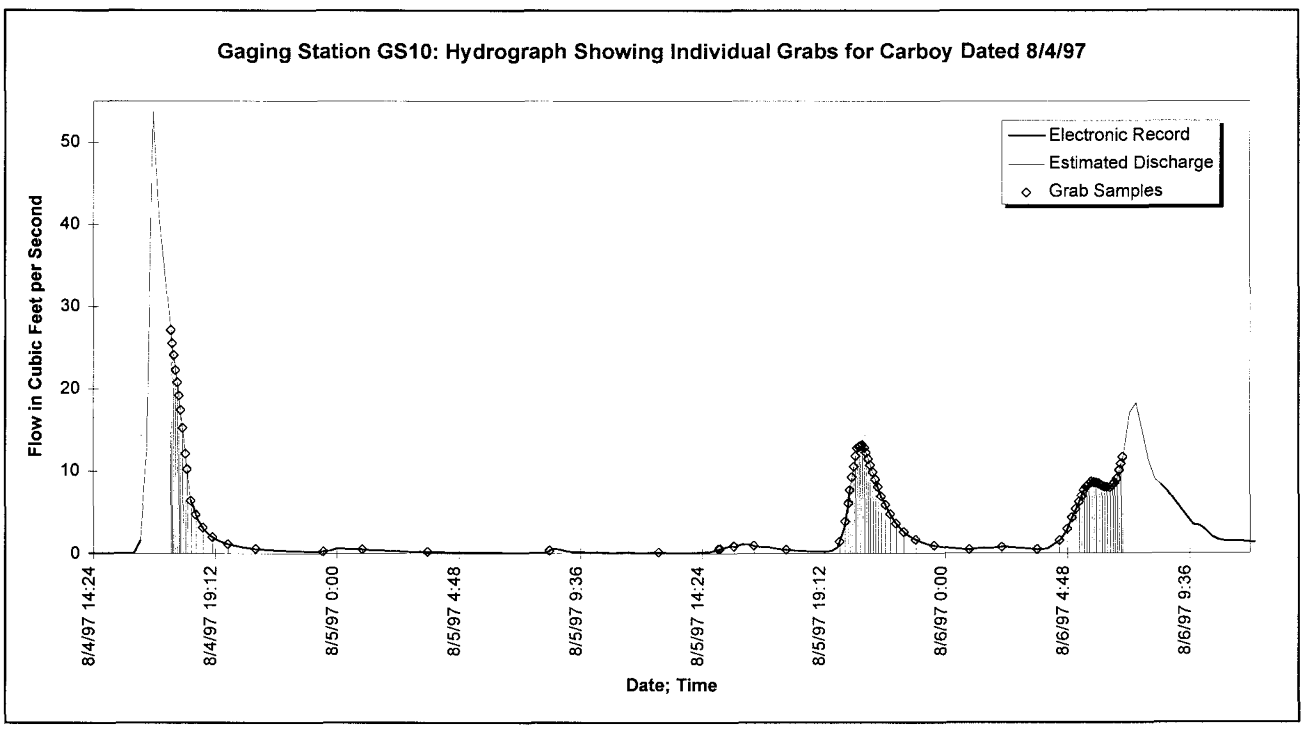

Figure 4-27. GS10 Hydrograph and Grab Samples for Composite Sample Dated August 4, 1997.

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Real-Time Water-Quality Parameters: Turbidity, Nitrate, Specific Conductivity, and pH

Average turbidity, nitrate, specific conductivity, and pH for each composite sample collection period was calculated by averaging the readings during each grab sample. Variation of Pu activity was plotted against the corresponding water-quality parameters. Figure 4-28 shows an upward trend for Pu activity with increasing turbidity. Assuming a relationship between Pu and TSS, this Pu turbidity trend is expected. No apparent relationships were observed between Pu and nitrate, specific conductivity, or pH. Figure 4-29 though Figure 4-31 for nitrate, specific conductivity, and pH do not exhibit significant trends.

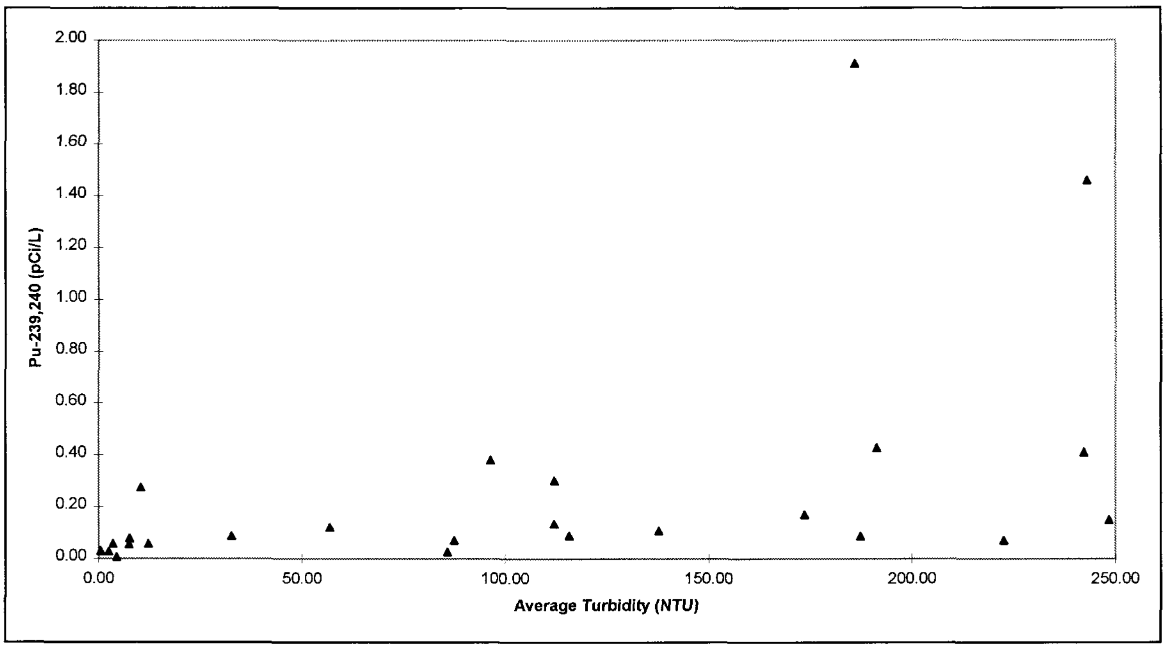

Figure 4-28. Variation of Pu Activity with Average Turbidity at GS10.

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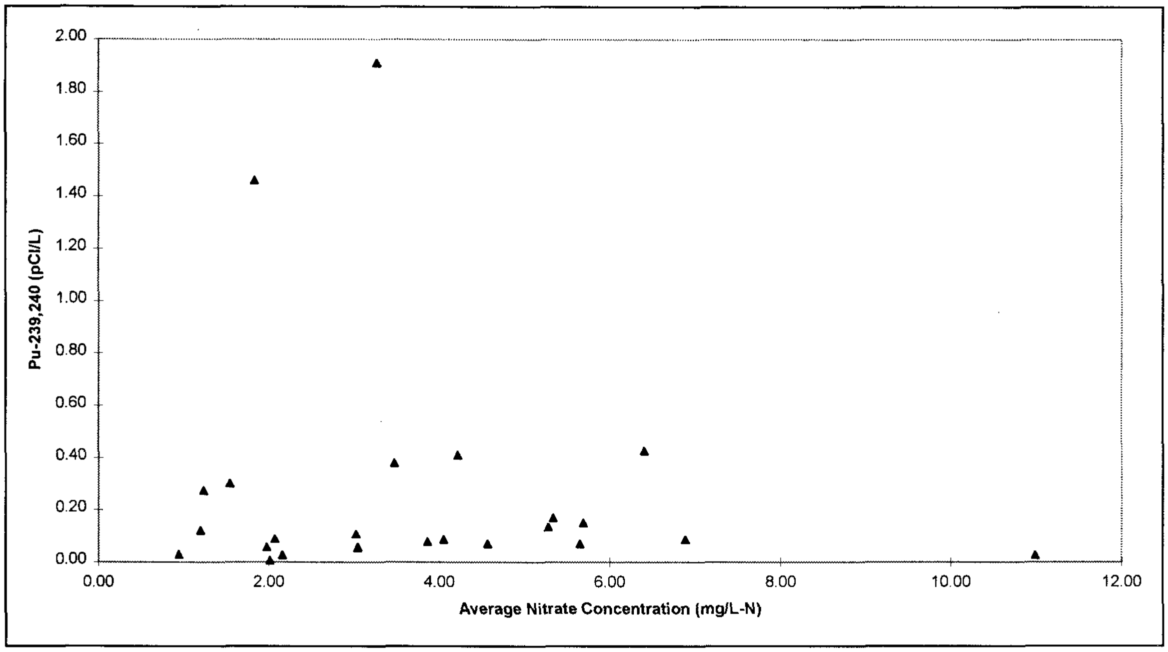

Figure 4-29. Variation of Pu Activity with Average Nitrate at GS10.

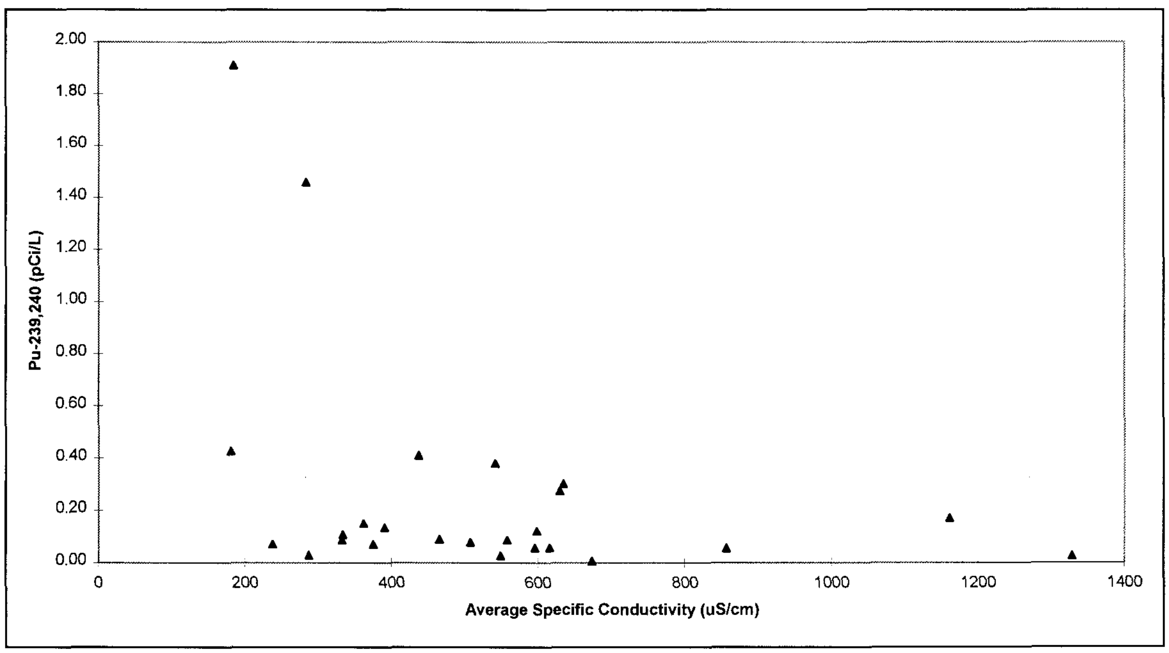

Figure 4-30. Variation of Pu Activity with Average Specific Conductivity at GS10.

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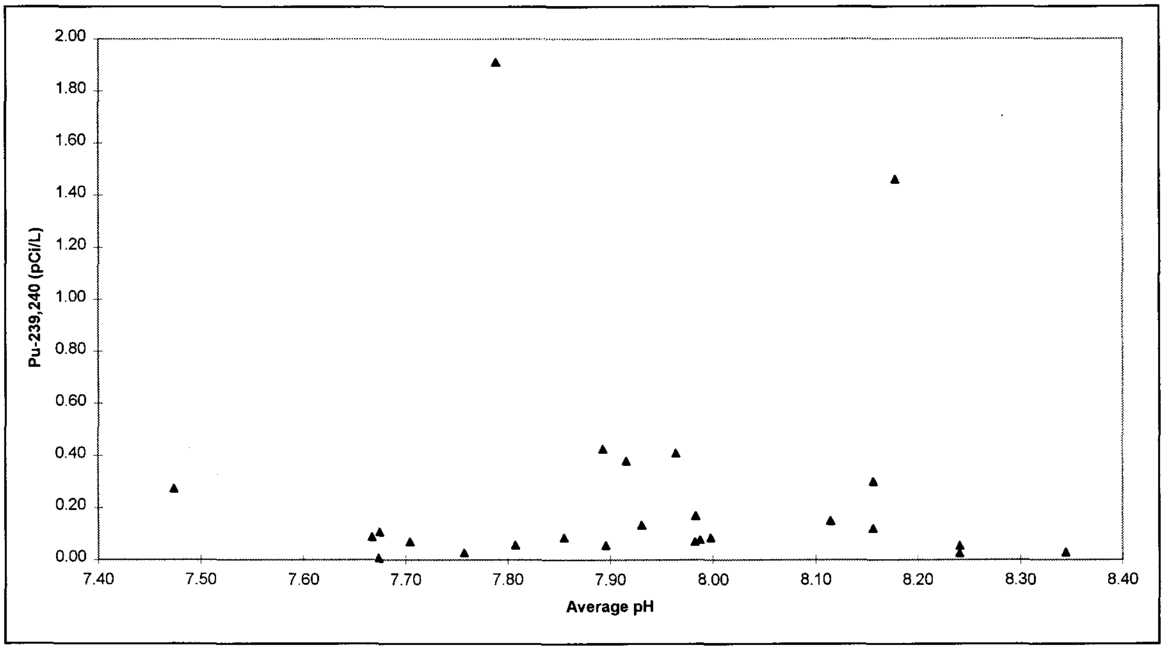

Figure 4-31. Variation of Pu Activity with Average pH at GS10.

4.3. SITEWIDE SURFACE-WATER DATA

A review of historical reports and analysis of historic data provided the basis for this investigation of surface water Pu concentrations within the GS10 drainage basin. Reports consulted include the Final Interim Measures/Interim Remedial Action (IM/IRA) Decision Document for the Rocky Flats Industrial Area (November, 1994) and the IA IM/IRA Surface Water and Sediment Historical Data Investigation (July, 1995). The IM/IRA reports provided a reference for characterization of radiochemical contamination in the IA. These reports were based on reviews of prior characterization studies and included analyses of information about the geochemistry of stream waters, seep/spring water, stream and seep/spring sediments, groundwater, and geologic materials.

In-situ gamma spectroscopy data collected by EG&G in 1992 and 1993 using a high-purity germanium (HPGe) detector show potential sources of Pu and Am contamination in surficial materials between Buildings 664 and 559 and north of Building 779. These contaminated areas may provide a significant runoff with Pu contamination to both GS10 and SW093. HPGe data are further discussed in Section 4.5.

Further, the reports agreed with some of the conclusions presented in Progress Report #1 regarding Pu transport at the Site. Specifically, these reports supported the hypothesis that Pu and Am are transported on particulates while U is transported primarily as a dissolved constituent. As discussed in Section 4.2, a significant correlation is observed when comparing the Pu activity with total suspended solids at GS10. Figure 4-17 indicates that Pu activity appears to increase with increasing TSS. The TSS/Pu relationship is well defined for some sampling locations such as GS10, but poorly defined for others. This relationship is also discussed in Section 4.2.

Historic data for this investigation were derived from the Rocky Flats Soils and Water Database (RFSWD, formerly RFEDS). Only sampling locations tributary to GS10 were included in this investigation (see Figure 4-32 for locations). Tributary sampling locations were identified using the Site's Geographic Information System (GIS) to select sampling locations within the GS10 drainage boundaries. The GIS generated sampling location list was used to formulate an RFSWD query for historic radioanalytical data. The query produced 3,865 radioanalytical data records, which were sorted by location and analyte type. The sorted data were limited to only results for field real samples with laboratory-reported target results. The filtered data were inspected and mapped to identify portions of the GS10 drainage basin associated with high Pu contamination in surface-water runoff. These maximum Pu concentrations are presented here in Table 4-4 and posted in map view on Figure 4-32.

Table 4-4. Maximum of Total Pu Activity for Each Sampling Location.

Location Code	Maximum Measured Pu Activity in pCi/L	Sample Date
995EFF	0.105	May 6, 1995
GS27	90.000	June 28, 1995
GS28	0.852	May 9, 1996
SW019	0.004	April 12, 1991
SW020	0.150	April 12, 1991
SW022	0.905	May 9, 1996
SW056	0.019	December 19, 1989
SW059	0.177	September 27, 1995
SW060	0.036	September 17, 1991
SW061	0.300	March 2, 1995
SW101	0.036	December 19, 1989
SW122	0.696	May 29, 1991
SW123	0.014	May 29, 1991
SW132	0.383	March 12, 1993

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The highest surface-water Pu activity observed within the GS10 drainage basin was 90.00 pCi/L at gaging station GS27. GS27, located northwest of Building 884, was installed as a Performance Monitoring location to establish baseline water quality prior to the Building 889 D&D project. Baseline surface-water sampling detected these elevated actinides within the GS27 drainage area. Follow-up investigations included Field Instrument for Detection of Low-Energy Radiation (FIDLER) screening and drainage ditch sediment sampling. Sediment samples for the area immediately south of Building 884 exceeded background Pu levels. Subsequent mitigative actions, including application of soil stabilizer, the removal of actinide contaminated sediments, and possibly the D&D of B889, appear to have significantly improved water quality observed in runoff from the GS27 drainage area. A majority of the other IA surface-water sampling locations (i.e., GS28, SW020, SW022, SW059, SW061, SW122, and SW132) had maximum Pu activities in stormwater runoff at or above the RFCA Point of Evaluation (POE) action level of 0.15 pCi/L. At the downstream end of the Central Avenue Ditch, station SW022 had a maximum Pu value of 6.00 pCi/L. Another location worth mention is SW122, which receives flows from the 700 Area. SW122 had a maximum Pu value of 0.696 pCi/L. These waters will be monitored by one of the proposed Source Location monitoring stations discussed in Section 9.3.4.

4.4. DATA GENERATED BY RECENT SITE PROJECTS

Site closure activities, including building D&D work, ER projects, excavation work and routine day-to-day operations are ongoing continually at multiple locations around the Site. Activities conducted during FY97 were assessed to determine whether or not they represented a plausible source of the Pu that resulted in the elevated activities observed at Station GS10.

4.4.1. D&D Work

D&D activities occurred throughout the Site during FY97. These Site closure activities were examined, in conjunction with water quality sampling results, to assess whether or not there was a connection between D&D projects and elevated Pu activity measured in the runoff at downstream monitoring locations. D&D projects of interest included the following:

- The T690 complex, comprised of office trailers located south of Central Avenue and west of Eighth Street, was subjected to thorough radiation monitoring prior to being removed in late September as part of FY97 Site D&D activities. Surface-water sampling location SW022, which collects runoff from the south central portion of the IA (including the 690 trailers) had Pu activity of approximately 1.0 and 6.0 pCi/L in samples collected during high intensity precipitation events on July 30, 1997 and August 4, 1997, respectively. These results are an order of magnitude higher than the mean of 0.172 pCi/L for all the prior samples collected at that location. Most important, in terms of relating the high measured activity at SW022 with the D&D work, is that the removal of the 690 trailers occurred in late September

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1997, more than a month after the elevated Pu samples were collected[17]. Hence, D&D of the 690 trailers does not appear to be related to the elevated Pu activity observed at station SW022 and GS10.

- Buildings 980, 968, and 965, all located south of the Solar Ponds within the PA, were demolished in late September, 1997[18]. These structures are all located upstream from GS10 (but not within the SW022 drainage basin referenced above). Similar to the T690 complex, the 900 Area buildings were subjected to extensive radiation monitoring prior to being removed. Also similar to the T690 project, elevated Pu activity at GS10 was measured well in advance of the 900 Area buildings being razed and, thus implies that the D&D work was not a causal factor for radionuclides being released to the Site surface-water system.

- Four trailers located in the contractor yard, T891L, T891M, T891N, and T891A, were removed from their sites and placed on trailers for offsite transport. This work, which involved minimal soil disturbance, occurred in September 1997, after elevated Pu had already been detected at SW022 and GS10. Routine vehicle traffic in the contractor yard is likely to generate more soil disturbance than this D&D project.

- D&D activities, including glovebox stripouts and decommissioning work, were being conducted in Building 707 (within the GS10 drainage basin) at the time of the elevated GS10 samples. However, these activities were conducted within the confines of the building; no demolition work was performed during this time frame. The building provides a protective envelope for preventing releases to the environment and such activities are strictly controlled and monitored for radioactive releases by Radiation Control Technicians (RCTs). Accordingly, this D&D work is not thought to have been the source for radionuclides that caused elevated Pu activity in surface-water samples collected at GS10.

4.4.2. ER Projects

One major ER project occurred during FY97 within the drainage basin for sampling station GS10. Another major ER project occurred during FY96 that was not within the GS10 drainage basin, but was located approximately 500 south of GS10. These projects, the Mound Site and Trenches T-3/T-4, respectively, and their potential for impacting Pu activity measured at GS10, are described below.

The Mound Site

The Mound Site (IHSS 113) remediation project, located immediately west of the east inner gate (within the GS10 drainage basin), involved excavating soil contaminated with Volatile Organic Compounds (VOCs),

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[17] Verbal communication with D. Coyne, RMRS Maintenance, November 10, 1997.

[18] Verbal communication with D. Coyne, RMRS Maintenance, November 10, 1997.

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thermally treating the soil on site to remove the VOCs, and backfilling the excavation with the treated soil. It was the one ER project conducted in FY97 that involved significant soil disturbance.

Excavation work was initiated on March 21, 1997 and completed on April 8, 1997. During this period, approximately 725 cubic yards of material were removed from the excavation site and stockpiled in a contained Contaminated Soil Feed Stockpile (CSFS). The CSFS was located immediately west of the east inner gate, where the soil was held until it was thermally treated from August 5 to August 21, 1997. Following treatment, the soil was placed back in the void created by the original excavation. This soil return process occurred from September 3 to September 8, 1997[19]. The site was re-excavated in late September to retrieve fill material containing depleted uranium[20]. Final backfilling was completed to meet the September 30, 1997 project milestone.

The Mound Site activities are not thought to be a likely source of the Pu that caused the elevated GS10 activity levels for the following reasons:

- The Mound site area was bermed to prevent local runoff from contaminating Site surface waters. Incidental waters collected in the excavation or bermed area during the excavation process were sampled and sent to Building 891 for treatment. Sample results did indicate the presence of tetrachloroethane (up to 3.9 parts per billion), as expected, but gross alpha activities were not elevated (Barker, 1997).

- During the Mound excavation process, soil was surveyed in the excavator bucket by Radiological Control Technicians (RCTs) prior to being placed in a dump truck for transport to the CSFS. RCTs used Field Instruments for the Detection of Low Energy Radiation (FIDLERs) for this screening. No

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[19] *Closeout Report for the Source Removal at the Mound Site IHSS 113*, Revision 0, October 1997.

[20] As part of the Mound backfilling operation, three partially-filled 55-gallon drums of soil (approximately 50 gallons total equivalent volume) were emptied into the bottom of the Mound Site excavation. The soil, which originated as a remnant from the T3/T4 project, had been previously sampled and determined to be below the RFCA Tier II subsurface soil action levels for radionuclides. As a result, a determination was made by RMRS, KH, SSOC, DOE, EPA and CDPHE to place this soil in the Mound Site excavation. After the soil had been placed and the original Mound Site backfilling completed, it was determined that the initial analyses were in error. Re-analysis indicated that the soil was above the Tier I action levels for depleted uranium. The Mound Site was re-excavated and, on September 26, 1997, approximately 3 cubic yards of material were removed and placed into two half waste crates. The material was detected as "hot" using FIDLER instrumentation. Samples were then collected for gross alpha/beta below the hot spot location. Reference: *Closeout Report for the Source Removal at the Mound Site IHSS 113*, Revision 0, October 1997, p. 10.

soil was encountered with radiologic contamination levels requiring further isotopic characterization as stipulated in the Sampling and Analysis Plan (SAP)[21].

- Prior to the Mound excavation occurring, 33 subsurface samples from the excavation site were collected and analyzed for radionuclide content[22]. Per RFCA, the "sum-of-ratios" method was applied to evaluate the potential total dose from multiple radionuclides as they relate to Tier I subsurface action levels[23]. Results of this evaluation indicated that the RFCA Tier I subsurface soil action levels were not exceeded for any of the 33 collected, and hence, remedial action for radionuclides was not triggered under RFCA. The highest sum-of-ratios value for any soil samples from the Mound Site, as presented in Table 4-5, was 0.1963.[24] Because this sum-of-ratios value was less than 1, further radiological evaluation was not required prior to excavation of the Mound site.

Table 4-5. Sum-of-Ratio Value: Highest Mound Site Sample Result Compared with Tier I Action Levels.

Radioisotope	Concentration (pCi/g)	Tier I Action Level (pCi/g)	Ratio (Sample to Tier I)
Uranium-233/234	18.41	1738	0.0106
Uranium-235	1.376	135	0.0102
Uranium-238	101.1	586	0.1725
Americium-241	0.3572	215	0.0017
Plutonium-239/240	1.905	1429	0.0013
Total Sum-of-Ratio			0.1963

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[21] The rate of radiological screening was decreased from each bucket of excavated material loaded into the dump truck to a screening for every three buckets after radiological control personnel determined it unlikely that significant contamination would be encountered. Reference: *Closeout Report for the Source Removal at the Mound Site IHSS 113*, Revision 0, October 1997, p. 3.

[22] *Final Proposed Action Memorandum for the Source Removal at the Mound Site IHSS 113*, Revision 0, February 1997.

[23] The "sum-of-ratios" method quantifies the potential total activity in the soil, from multiple radionuclides, as they relate to the Tier I subsurface Action Levels. For a particular soil sample, a ratio is calculated (for each radionuclide isotope of interest) between the soil activity and the Tier I Action Level. If the sum of these ratios was equal to or greater than 1 (indicating that the cumulative effect of all the radionuclides exceeds the Tier I standard), then further radiological evaluation was required for the Mound site. The highest sum-of-ratios value calculated for any soil samples from the Mound Site was 0.1963.

[24] Sample result to Tier I ratios are shown for a sample collected from borehole 14295, sample number BH20837WC. Reference: *Final Proposed Action Memorandum for the Source Removal at the Mound Site IHSS 113*, Revision 0, February 1997, p. 10.

- Although the Mound Site had to be re-excavated prior to final backfilling (as noted earlier), to remove three cubic yards of fill material contaminated with depleted uranium, the contamination was not associated with Pu. Therefore, if the soil with elevated depleted uranium levels, temporarily buried in the Mound excavation, somehow came in contact with surface water, it would not have affected the Pu activity measured at GS10.

Trenches T-3 and T-4

The Trenches T-3 and T-4 (IHSSs 110 and 111.1) project site, remediated during the summer of FY96, is located immediately northeast of the east inner gate. This project was not located within the GS10 drainage basin, but is discussed in this report because the project site was approximately 500 feet south of GS10 and the potential for airborne contamination of the GS10 drainage basin warranted investigation.

The T-3/T-4 project involved excavating soil from the former disposal trenches (used from 1964 to 1966) and contaminated with VOCs, low levels of U and Pu, and miscellaneous debris[25]. The excavated soil was radiologically screened, segregated according to the screening results, treated onsite to remove VOCs, and then placed back into the excavation after it was determined by DOE, EPA, and CDPHE to be suitable for "putback" into the original excavation.[26]

Approximately 3,796 cubic yards of material were excavated and treated during the T-3/T-4 project (1,706 yards from T-3; 2,090 yards from T-4).[27] The Trench T-3 excavation was completed on July 3, 1996 and soil treatment completed on July 11, 1996. The Trench T-4 excavation was completed on August 14, 1996 and soil treatment completed on August 19, 1996.

During the T-3/T-4 project, each bucket load of the front-end loader was screened as the material was moved into the contaminated material stockpile. Any material reading above 5,000 counts per minute (cpm)(using a FIDLER) was segregated into a separate pile. Of the 3,796 cubic yards of material excavated and treated, approximately 500 cubic yards were above the 5,000 cpm threshold and were segregated as being potentially radiologically contaminated. This soil was kept segregated before, during and after the thermal VOC-removal process.

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[25] *Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSS's 110 and 111.1)*, Revision 2, September 23, 1996, p. 1.

[26] *Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSS's 110 and 111.1)*, Revision 2, September 23, 1996, p. 9.

[27] *Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSS's 110 and 111.1)*, Revision 2, September 23, 1996, p. 1.

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Following treatment, samples were collected for radionuclide isotopic characterization using gamma spectroscopy. Results of this sampling indicated that all of the soil, including the radiologically segregated material, met the Tier I action levels and that all but 250 cubic yards of the soil met the more stringent Tier II action levels as well. After discussions with the DOE, EPA, and CDPHE, it was decided that all of the treated soils (including the material that exceeded Tier II levels) could be backfilled into the trenches. The material that exceeded the Tier II levels was separated from the other backfill material using a geotextile liner to facilitate any future re-excavation should it become necessary.[28]

It should be noted that U-238, not Pu, was the cause of the Tier II levels being exceeded. Summary Pu statistics are provided in Table 4-6 for samples from the T-3/T-4 soil that was segregated as being potentially radiologically contaminated[29].

Table 4-6. T-3/T-4 Radiologically Segregated Soil Samples - Pu Activity Versus Tier I and Tier II Levels.

Mean Pu Activity (pCi/g)	Max. Pu Activity (pCi/g)	Tier I Soil Action Level	Tier II Soil Action Level
7.36	15.57	2001.00	353.20

Trenches T-3 and T-4 involved the excavation of more radiologically-contaminated material than the Mound project. Hence, the T-3/T-4 project appears to be more likely than the Mound project to have contributed the Pu that caused elevated measurements at GS10, particularly when airborne transport mechanisms are considered. However, for the following reasons, the T-3/T-4 project probably did not contribute Pu to the drainage basin above station GS10:

- Trenches T-3 and T-4 are separated from station GS10 by a spur of the Central Avenue Ditch (not frequently used) that ties into South Walnut Creek above Pond B-5. Overland flow from the T-3/T-4 project site is hence diverted away from GS10.

- T-3 and T-4 activities occurred in the Summer of FY96. Elevated Pu activity at GS10 was not detected at GS10 until April, 1997.

- Control measures were in place throughout the T-3/T-4 project to minimize the transport of contaminated material from the project site. Untreated soil in the CSFS was surrounded by a drain system that captured stormwater runoff, which was collected and sent to Building 891 for treatment.

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[28] *Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSS's 110 and 111.1)*, Revision 2, September 23, 1996, p. 9.

[29] *Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSS's 110 and 111.1)*, Revision 2, September 23, 1996, Appendix D, p. 3.

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Tarps were used to cover the untreated soil to prevent precipitation from leaching through the soil and to control dust, and ConCover® was applied to the treated soil to prevent erosion and airborne transport.

4.4.3. Excavation Work and Routine Site Operations

Excavation work and routine operations at the Site are subject to the Site Incidental Waters program. Water collected in utility pits, valve vaults, or excavations is sampled prior to being dispositioned. Following sampling, such water is pumped to the ground if the water quality is acceptable, or sent to an onsite treatment facility if sample results indicate the water is not suitable for a release to the environment.

One construction project that involved significant excavation upstream from GS10, the influent and effluent tanks for the Waste Water Treatment Plant, did turn up radiological contamination in November, 1996. Incidental water collected in excavations during this project were managed per the Site Incidental Waters program. Contaminated soils were detected and subsequently cleaned up. However, GS10 sample results, as discussed earlier in this report, were not elevated during this time frame (GS10 did not have elevated Pu until April 1997).

4.4.4. Summary of Recent Site Activities Impact on GS10

For the reasons outlined above, it is inferred that neither D&D, ER, excavation, nor routine operations caused a release of Pu that resulted in the elevated Pu activities measured at station GS10. Rather, it is implied that the elevated activities are attributed to Pu source(s) created by atmospheric fallout, historic Site operations, and natural actinide transport processes.

4.5. GAMMA SPECTROSCOPY INFORMATION

In FY93 and FY94, IA Operable Units were surveyed by gamma spectroscopy instrumentation using an HPGe detector. The HPGe instrumentation was used to measure Am-241 activities in IA surficial soil materials. Am-241 is a decay product of Pu, hence it is an important indicator of potential Pu sources. These gamma spectroscopy data are of somewhat limited utility because of the large radius of investigation (approximately 30 feet) used for the measurements. This radius of investigation created the potential for monitoring results to be errantly impacted by activity emitted from within nearby buildings, often referred to as "shine," and also to miss small, localized activity sources. With these factors in mind, the results from this survey were reviewed as part of the GS10 source investigation.

Data mapping indicates that, within the GS10 drainage basin, elevated surficial transuranic activity may exist in the soils near Buildings 569 (all sides), 664 (north side), 707 (south, west, and east sides), and between the 903 and 904 Pads.

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4.6. SOIL AND SEDIMENT INFORMATION

A review of historical reports and analysis of historic data provided the basis for this review of soil and sediment Pu concentrations within the GS10 drainage basin. As for the surface-water review, this soil and sediment review relied on information in the Final IM/IRA Decision Document for the Rocky Flats IA (November, 1994) and the IA IM/IRA Surface Water and Sediment Historical Data Investigation (July, 1995).

The IM/IRA soil monitoring program sought to characterize temporal changes in Pu concentrations, as spatial and vertical distribution of Pu according to specific remediation areas. The program consisted of annual sampling for Pu and Am at 1 and 2-mile radii from the center of the plant. This grid was chosen to investigate Pu distribution patterns using the IA as a point source. Samples were collected from 40 sampling locations and evaluated for changes in Am and Pu concentrations as a result of soil resuspension or other mechanisms. The minor temporal variations observed were attributed to heterogeneity of the wind-deposited actinides in soil. Pu and Am concentrations at annual sampling locations outside the IA exhibited much less variation and were typically at or near background concentrations.

Historic radioanalytical data for this soil/sediment assessment were also retrieved from RFSWD. Only sampling locations tributary to GS10 were included in this investigation (see Figure 4-35 for locations). Tributary stations were identified by GIS were used to formulate an RFSWD query for historic radioanalytical data. The query produced 4,194 radioanalytical data records, which were sorted by location and analyte type. The data were then filtered to limit the analysis to only representing field real samples with laboratory reported target results. The maximum Pu concentration values for each location were selected from the filtered data set which resulted in 385 values for statistical analysis. To evaluate the data, a frequency distribution plot was generated using the logarithmic sized bins (i.e., <-0.010, 0.000, 0.010, 0.100, 1.000, 10.000, 100.000, 1,000.000, 5,000.000, and > 5,000.000) for grouping maximum Pu values. The results of the analysis are plotted in Figure 4-34 and presented in a color coded map view on Figure 4-35. For the map view, colors were selected to grade from low Pu concentrations to high Pu concentration (i.e., black through green, to yellow, to orange and ending red) to identify areas of high Pu contamination.

A review of the soil and sediment maximum values indicate orders of magnitude differences Pu concentrations for contaminated soils and sediments within the IA. Most of the maximum Pu values, 153 occurrences, were observed in the 0.010 to 1.000 pCi/g range. The second greatest count, 115 occurrences, were observed in the 0.100 to 1.000 pCi/g range. The overall distribution was log normal, as is expected of actinide contamination data. The extreme high values, 2 in the 100 to 1,000 pCi/g and 2 in the 1,000 to 5,000 pCi/g range, are associated with the 903 Pad and the 444 Parking Area. These areas are currently covered by pavement. The highest Pu value, 4,206 pCi/g, was measured at sampling location TR08.

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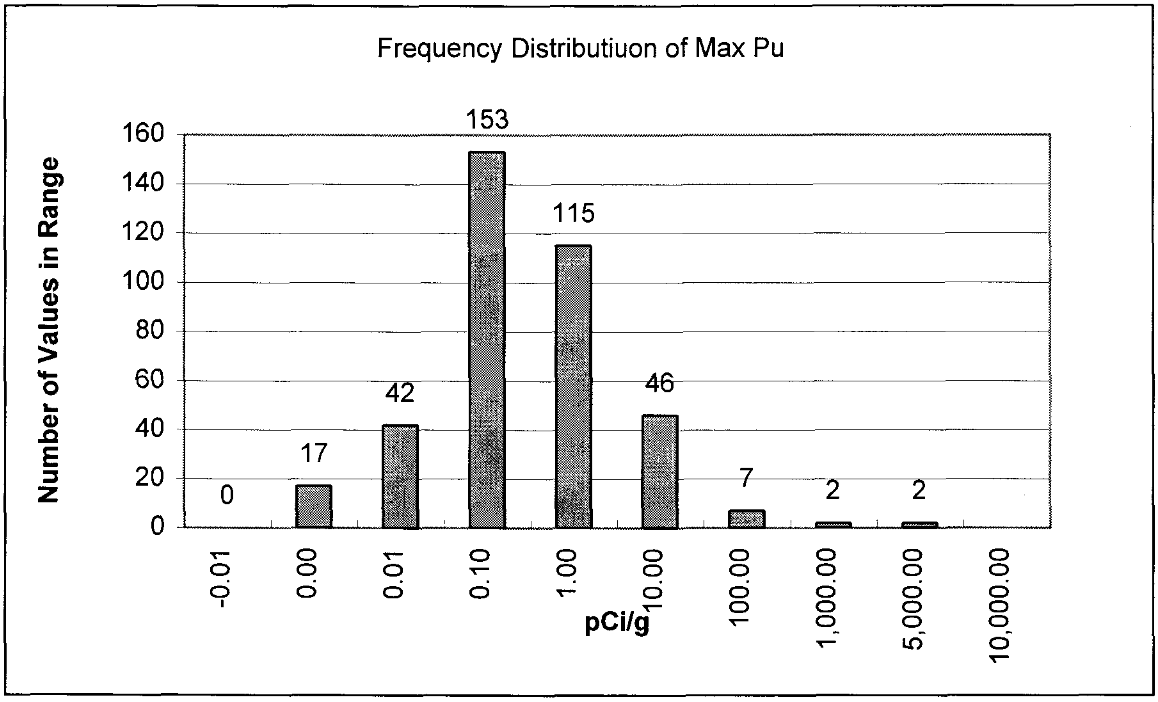

Figure 4-34. Frequency Distribution of Maximum Pu Activity for Sampling Locations Within the GS10 Drainage Basin.

4.7. HISTORICAL RELEASE REPORT[30] INFORMATION

A multitude of potential sources of radionuclide contamination exist within the boundaries of the GS10 drainage basin. From the Site Historical Release Report (HRR), 32 Pu and general radionuclide-contaminated IHSSs were identified to be completely or partially within this drainage. The Pu IHSSs are listed and described in Table 4-7.

General radionuclide IHSSs include PAC #'s 122, 123.2, 148, 150.5, 153, 157.1, 157.2, 158, 159, 162, 164.1, 164.2, 164.3, 173, 176, 179, 180, 182, 194, and 213.

These IHSSs resulted from a variety of incidents and activities including spills from process waste lines and waste boxes, exposed storage of contaminated equipment following fires, burning of contaminated oil, release from unfiltered fume hoods, and overflow from a valve vault. In addition to recorded IHSSs, the GS10 drainage contains multiple exposed-dirt parking surfaces and roads.

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[30] U.S. Department of Energy, 1992, *Historical Release Report for the Rocky Flats Plant*, Rocky Flats Environmental Technology Site, Golden, CO, June.

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General radionuclide IHSSs in the GS10 basin originated from process waste line leaks, overflow of process waste tanks and valve vaults, burning of contaminated oil, and exposed storage of equipment and drums. Details of some of these releases are compiled in the following paragraphs. This information is not intended to be complete, due to the number of IHSSs, but rather it is intended to be representative of the types of events that have occurred which may have led to potential contamination sources within the basin.

The HRR mentions numerous incidents of leaking process waste lines and overflowing process waste tanks. The original process waste lines were constructed of a type of iron that leaked considerable amounts of waste without personnel being aware of the leaks. Recorded occurrences include an overflow of a valve vault west of B707, which spilled 4,000 gallons of process waste (December, 1958), and a rupture of the process waste line from B559, which caused soil contamination with an activity of 4,500 pCi/g (1972). Process waste leaks were also recorded from B123 and 441 (1953-1975).

Drums containing oil contaminated with uranium were burned in an open pit located north of Central Avenue and southeast of B991(March, 1957-May, 1965). Activity in the contaminated water in the pit was measured between 12,000 and 300,000 dpm/L. B991, the first plant structure to become active, was used for the assembly and storage of components (1952). Incidents involving spills of radioactive materials occurred frequently on the south dock of the building. The area north of B991, known as the S&W Contractor Storage Yard, was potentially contaminated with radioactive nitrate spray from the adjacent solar ponds (1960-1980). The soil and groundwater in the immediate vicinity of the ponds is also believed to be contaminated.

Exposed storage of equipment and drums, and various other leaks and spills have led to contamination within the GS10 basin. A glovebox being moved from a storage area leaked contaminated oil onto the roadway at the intersection of 7th Street and Central Avenue (May, 1965). The oil had alpha counts greater than 100,000 cpm. Leakage of waste boxes being loaded into railroad container cars is suspected of causing residual contamination in the area north of B551. Shipments measuring 6,000 to 40,000 cpm were held back at this location (September, 1959). The ground surface northwest of B881 was used for storage of a concrete slab contaminated during a fire in B776/777 (September, 1957). Because the slab originated from a building where plutonium was manufactured, it was thought likely that Pu contaminated the slab. Other potentially contaminated areas include the dock and helium storage area of B553, which showed isolated spots of contamination up to 8,000 cpm (June, 1961), and, the drum storage areas of B883 and 865, where drums of radioactive wastes were held.

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Table 4-7. Pu IHSSs Located in the GS10 Drainage[30].

IHSS #	Location/Bldg.	Dates	Description
108	900 Area, Trench T-1	November. 1954 - December 1962	Approximately 125 drums of depleted uranium chips and lathe coolant were buried in the trench. One drum reportedly contained an oily sludge with 4.3 pCi/g Pu.
109	900 Area, Trench T-2	July 1954 - August 1968	The trench received sewage sludge from the on-Site WWTP in addition to some crushed empty drums. The sludge was contaminated with uranium and Pu. This trench may have been primarily used for the disposal of non-radioactive liquid wastes.
112	900 Area, 903 Pad	1955 or 1958 - June 1968	1500 drums were stored on the 903 pad beginning in 1958. by 1960, significant leaking was noticed, and 50 drums had drained entirely. Heavy rains in 1967 resulted in the spread of Pu. Drum removal activities also resulted in the release of Pu.
113	900 Area, Mound Area	April 1954 - September 1958	In 1954, drums of contaminated combustible material from B444 were buried in a shallow trench and covered with soil. Several of the drums were reported to have contained pinhole leaks. Drum contents included depleted and enriched uranium and some limited Pu. All drums were removed by 1971.
141	900 Area	1952 - present	Several incidents have occurred when sludge from the WWTP overflowed the drying beds or was dispersed by wind.
150.4	700 Area, NW of B750	May 1969, 1980, and 1981	Tanks and pumps which handled decontamination fluid during the May 1969 fire were placed in the B750 courtyard. This area is suspected to have residual Pu contamination.
150.7	700 Area, S. of B776.	May 11, 1969	Following the May 1969 fire in B776/777, Pu tracked outside by fire fighting personnel was carried into the soil by rain. Airborne contamination was carried primarily to the southwest.
155	900 Area, 903 Lip Area	1964 - 1973	Contamination from the 903 Drum Storage Area was spread by wind and rain to adjacent soil.
157.1	400 Area, B442	1953 - unknown	B442 was used as a laundry facility to clean contaminated clothing from 1953 until approximately 1972. Soil samples taken in 1954 indicated the existence of contamination ten times greater than background in the ditches near B442. In 1962, barrels containing rags containing solvents and radioactive metal shavings was either spilled or leaked. The liquid drained east into the ditch north of B442.

IHSS #	Location/Bldg.	Dates	Description
160	B444 Parking Lot	Prior to 1959 - Present	Drums and boxes of waste were stored on an unpaved area in great quantity. In particular, waste from the May 1969 fire in B776 and B777 was stored here. On May 24, 1971, two boxes leaked an unknown contaminated liquid onto the ground. Approximately 1000 ft^2 were contaminated from 1,000 cpm to greater than 100,000 cpm.
165	900 Area, Triangle Area	1966 - 1975	In 1968, more than 6,000 drums were stored in an open field. High winds blew over as many as 150 drums at a time. The drums contained recoverable Pu-bearing wastes and residues. Scrap material also awaiting Pu recovery was also stored in the triangle area.
172	Central Avenue	June 11, 1968	A drum being transported from the 903 Drum Storage Area to B774 leaked, causing contamination to the roadways traveled. Radioactive materials spilled include Pu-contaminated oils and radioactive waste oil.
214	750 Pad		Multiple incidents of spilled or leaked pondcrete and saltcrete were reported in 1988, and 1989. Pondcrete consists of solidified low-level radioactive and hazardous waste extracted from the Solar Evaporation Ponds. Saltcrete consists of solidified low-level radioactive and hazardous waste extracted from process waste at B374 by distillation.

Outside of the IA, numerous radioactive releases were made to the B-series ponds that may have potentially contaminated the soil and sediment in the GS10 basin. Untreated process waste, primarily decontamination laundry wastewater from B774, was released from at least July, 1953 until January, 1954, and decontamination laundry wastewater from B771, was released from at least July, 1953 until 1965. These wastes were discharged to Pond B-2 from an outlet below B995, the WWTP. In addition, low level radioactive laundry effluent was known to have entered the WWTP and flowed into the B-series ponds. In 1967, a survey noted that the sanitary sewer system averaged a total daily flow of 250,000 gallons, of which 21,000 gallons was laundry waste. A 1973 investigation of Pu releases to the sanitary sewer system indicated that 88% of the Pu originated from laundry waste. Beginning in December, 1978, discharges from the sanitary sewer were rerouted from the outfall to Pond B-3.

An RFP study completed in June, 1973 confirmed the presence of radioactive sediments upstream from the B-series ponds, where GS10 was eventually constructed. The area from the culvert west of the B995 outfall, to the culvert immediately east of the outfall, had an average activity concentration of 40 dpm/g. The contaminated area was estimated to cover an area of 650 feet (length) by 6 feet (width). In November, 1973, contaminated soil was supposedly removed from the B995 outfall, but no documentation was found regarding the disposition of the soil, or whether analyses were done of the surrounding soil following the removal. A sediment study conducted by Colorado State University (CSU) further indicated radioactive contamination of sediments in the B-series drainage and found Pu activities from 10 to 502 pCi/g of dry sediment in Pond B-1.

It is evident that Site sediments in the GS10 drainage basin have a lengthy history of contamination from historical releases. Documentation is limited however, regarding the fate and mobility of contaminants in the environment from a particular IHSS. Many of the IHSSs described above contain similar constituents, are in close proximity to each other, and oftentimes overlap. The isolation a particular IHSS as the sole contributor to elevated radionuclide levels at GS10 is unlikely. Multiple IHSSs could collectively be the single source of contamination. Activities took place concurrently with historic releases which may have affected the migration of contaminants from their source of origin. Construction and maintenance of dirt parking surfaces and roads common in the IA make it reasonable to expect that vehicular traffic provided a source of mobility of potentially contaminated surficial soils. Additionally, storm events, characterized by heavy rains and high winds, were frequent mechanisms for dispersion of contaminants. While future investigations take place to further characterize the above IHSSs with respect to the magnitude and extent of contamination, historical information currently supports the existence of widespread contamination throughout the GS10 drainage basin.

4.8. GROUNDWATER DATA

All groundwater data discussed in this document were retrieved from RFSWD for wells within the GS10 drainage. The RFSWD query yielded data from September, 1986 through January, 1997. All radionuclide activity results discussed are unfiltered, total radionuclides. Samples rejected in the data validation process were not considered. Duplicate samples and laboratory replicates were averaged with real samples as appropriate.

4.8.1. Groundwater Monitoring Near GS10

The uppermost, unconfined aquifer within the GS10 drainage flows from west to east across the Site through the Rocky Flats Alluvium and Arapahoe and Laramie Formations. There is no known direct hydraulic connection between this shallow alluvial aquifer and deeper confined aquifers extending off-Site (Kaiser-Hill, 1994). In the spring and early summer, this shallow alluvial aquifer of the Rocky Flats Alluvium and Arapahoe Formations is recharged by precipitation and lateral groundwater flow. In the late summer and early fall, these formations are recharged primarily by groundwater lateral flow. In the Walnut Creek stream drainages, groundwater discharges as seeps which typically occur at the base of the Rocky Flats Alluvium where individual sandstone lenses become exposed to the surface (Kaiser-Hill, 1994). Such apparent seeps have been observed by Surface Water personnel on the hillside just upgradient from GS10 in the spring.

In accordance with the IMP (DOE, 1996), the uppermost unconfined aquifer is currently monitored for Pu-239,240 and Am-241 in three alluvium monitoring wells within the boundaries of the GS10 drainage: 3386, 3586, and 75992 (Figure 4-37). Sampling from these wells is performed semi-annually. The RFSWD contains records of historical Pu-239,240 and Am-241 sampling in 37 wells across the GS10 drainage, dating back to 1986. Historical sampling frequencies for many of these wells are not clear, varying between weekly and semi-annual. All groundwater samples discussed in this document were collected using bailers.

4.8.2. Summary of Groundwater Data

Groundwater data considered in this analysis were limited to total unfiltered Pu-239,240 and Am-241, TSS, and groundwater table elevations. Complete records of available data are presented for wells in the GS10 drainage currently sampled for Pu-239,240 and Am-241; however, due to the size of the historical data set, only summary values are presented for wells no longer in the groundwater sampling routine for radionuclides.

Pu-239, 240 and Am-241 Data

Of the 37 wells sampled intermittently since 1986, only eight yielded samples with total Pu-239, 240 and Am-241 activities greater than 0.15 pCi/L. These results are summarized in Table 4-8. All wells with total Pu-239, 240 and Am-241 sample activities exceeding 0.15 pCi/L monitor the uppermost aquifer, with the exception of wells 1686 and 5671 which are lower hydrostratigraphic unit monitoring wells. Locations of these wells are identified in Figure 4-37. Of these eight wells, six are in the immediate vicinity of the 903 Pad. Well P313489 is located roughly one half mile upgradient of the 903 Pad in the area of the B444 parking lot, the location of radiological IHSS 160. Well 5671 is located east of B122.

Table 4-8. Historically Sampled Groundwater Wells in the GS10 Drainage with Total Pu-239, 240 and Am-241 Activities Greater than 0.15 pCi/L.

Well Number	Sampling Period	# Samples	Max. Pu-239,240 (pCi/L)	Max. Am-241 (pCi/L)
1587	Jan. 1990 - Mar. 1995	11	4.3	0.65
1687	Jun. 1990 - Jun. 1995	16	0.42	none > 0.15
2387	Feb. 1990 - Nov. 1992	11	none > 0.15	0.22
5671	March 1994	1	0.47	0.15
12091	Dec. 1991 - May 19995	14	none > 0.15	1.1
13191	May 1992 - Jun. 1995	12	5.0	0.6
20591	July 1994	4	0.23	none > 0.15
P313489	Nov. 1993 - Nov. 1996	13	1.6	0.26

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Total radionuclide activities in samples collected from currently sampled groundwater wells in the GS10 drainage, 3586 and 75992, are presented in Figure 4-38 and Figure 4-39, respectively. No radionuclide sampling data were available in RFSWD for the third currently sampled well, 3386. As seen in Figure 4-38 and Figure 4-39, total Pu-239, 240 and Am-241 activities in wells 3586 and 75992 are low and show no significant trends with time.

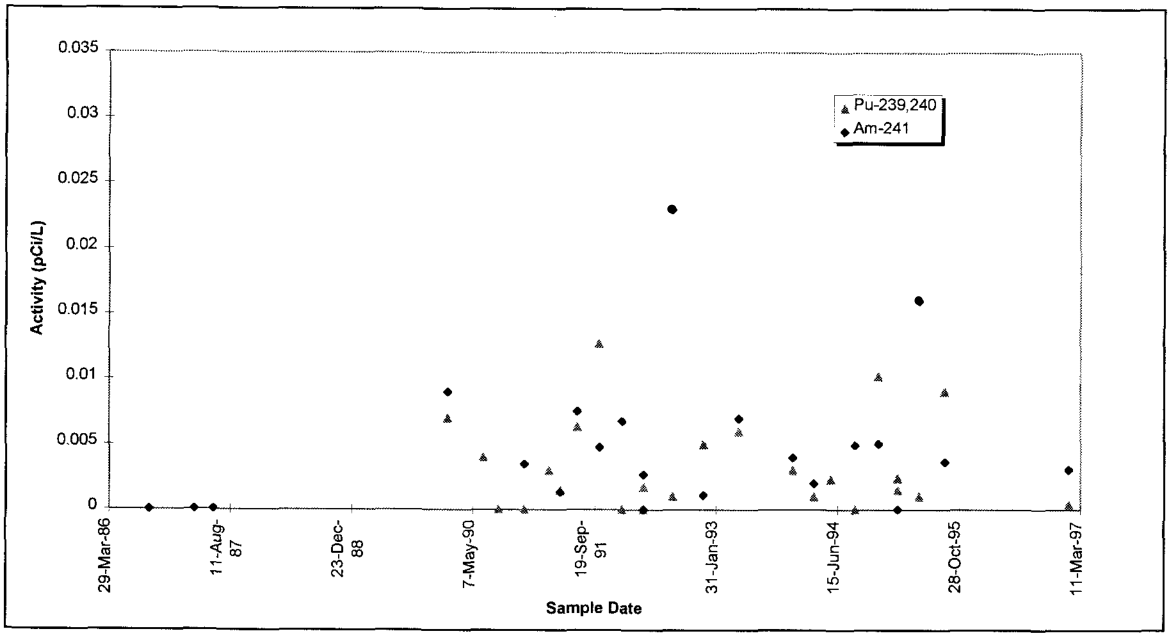

Figure 4-38. Total Pu-239,240 and Am-241 in Groundwater Samples from Well 3586.

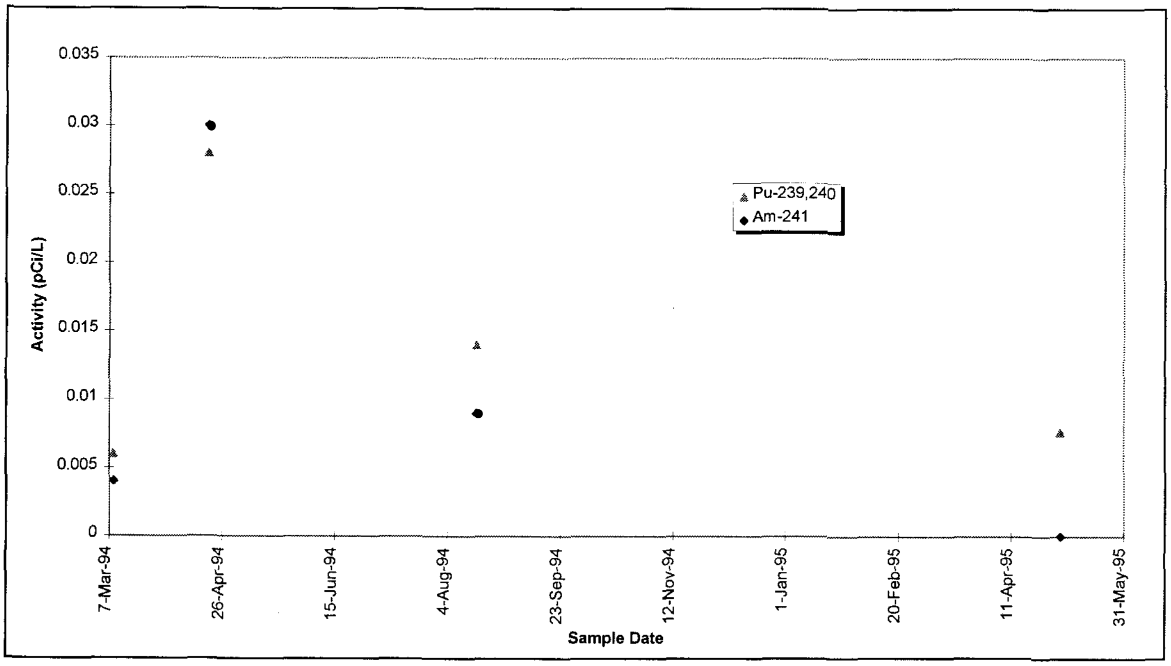

Figure 4-39. Total Pu-239, 240 and Am-241 in Groundwater Samples from Well 75992.

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Due to significant delays in data availability in RFSWD, the most recent results presented here are from January, 1997 for wells currently sampled in the GS10 drainage. Table 4-9 presents the most recent sampling dates for the three wells in the GS10 drainage currently sampled for radionuclides. Analytical results are not yet available for these sample dates which encompass the sample dates for which elevated values of radionuclide activities were observed in surface water at GS10.

Table 4-9 Log of Recent Groundwater Samples Taken Within the GS10 Drainage with Radionuclide Results Pending.

Well Number	Sampling Date
3386	January 6, 1997 June 16, 1997
3586	August 28, 1997
75992	November 13, 1996 August 27, 1997

Total Suspended Solids Data

TSS data from wells 3586 and 75992 are presented in Figure 4-40. For these wells, TSS data vary between 5 and 170 mg/L, showing no apparent trend with time. In contrast, wells identified in Table 4-8 as having elevated total Pu-239, 240 and Am-241 activities also exhibit significantly higher TSS values. TSS values for these wells vary between 20 and 5,700 mg/L, with more than 60% of values greater than 170 mg/L. An explanation for this, considering and well installation techniques, is presented in Section 8.3.

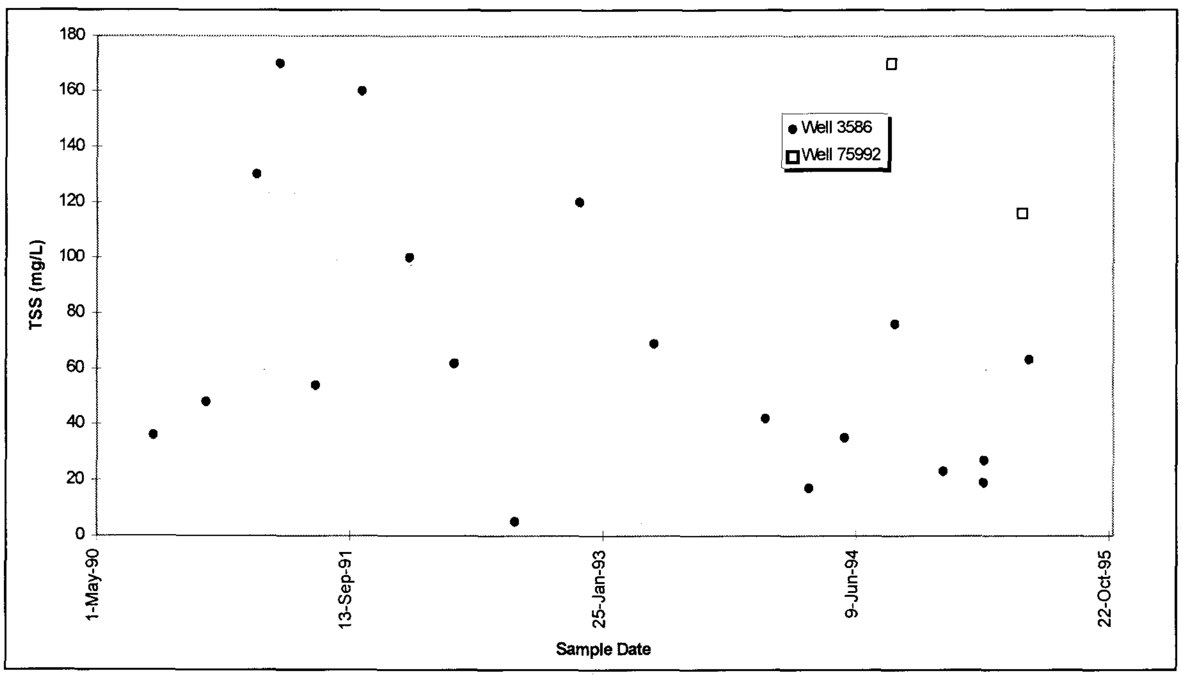

Figure 4-40. Total Suspended Solids Concentrations in Groundwater Samples from Wells 3586 and 75992.

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Groundwater Table Elevation Data

Groundwater table elevation is measured monthly to quarterly at all actively sampled wells. Groundwater table elevation data from the three wells in the GS10 drainage currently sampled for Pu-239, 240 and Am-241 are statistically summarized in Table 4-10.

Table 4-10. Summary of Groundwater Table Elevations for Wells 3386, 3586, and 75992.

Well Number	Mean (ft. above sea level)	Maximum (ft. above sea level)	Minimum (ft. above sea level)
3386	5945.0	5947.1	Dry
3586	5904.1	5908.1	5898.8
75992	5890.1	5894.5	5885.9

Comparison of mean groundwater elevations indicates that, as expected, water table elevations in the uppermost aquifer decrease from west to east in the GS10 drainage. The elevation of the creek bed at GS10 is approximately 5882 feet above sea level. Consequently, both groundwater table elevations and geology of the area suggest that groundwater seeps contribute to the surface-water flow at GS10. No efforts, however, have been made to quantify the groundwater contribution. Groundwater elevation record is displayed graphically in Figure 4-41 for Well 3586 as an example of seasonal variation.

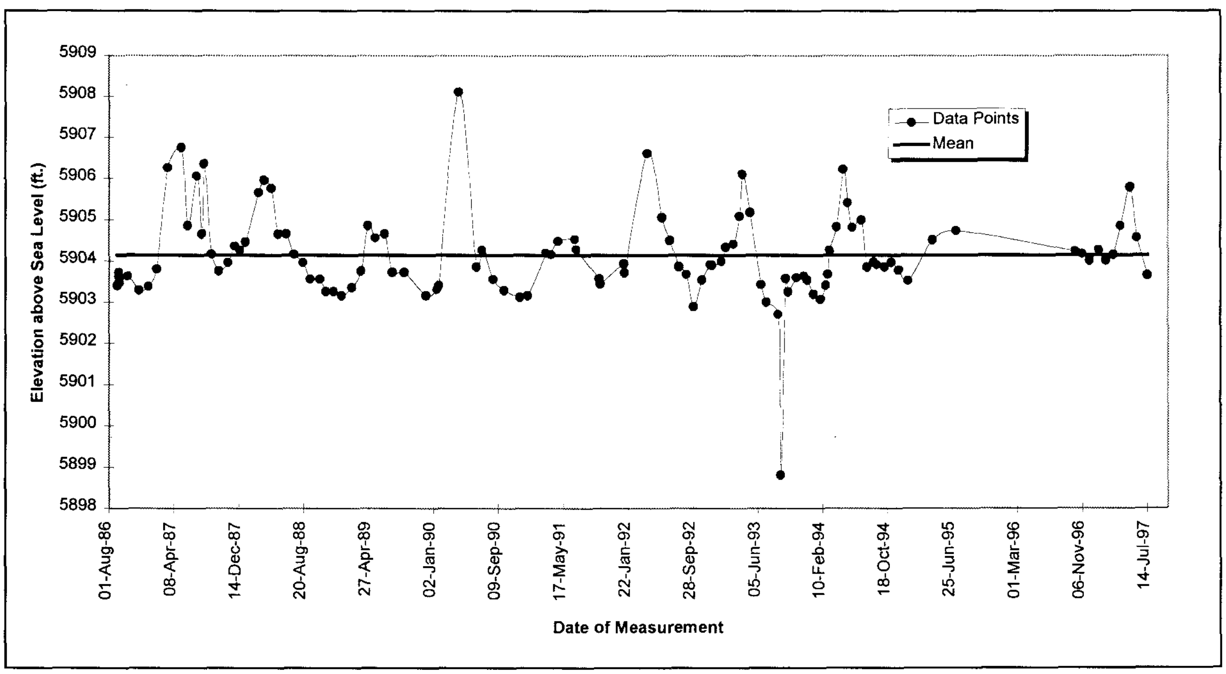

Figure 4-41. Groundwater Table Elevation in Well 3586.

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4.8.3. Analysis of Groundwater Data

Elevated Pu-239,240 and Am-241 Activities in Groundwater

Elevated Pu-239,240 and Am-241 activities in groundwater samples identified in Section 4.8.2 do not necessarily indicate significant groundwater radionuclide contamination. These samples may not be representative of the actual mobile contaminant load in the groundwater for two reasons.

First, all wells identified with Pu-239,240 and Am-241 activities greater than 0.15 pCi/L were drilled prior to adoption of improved well installation techniques (1992). The improved ("aseptic") drilling technique was designed to prevent contamination of the borehole by contaminated surface soils during well installation. Technical specialists in the groundwater program determined, when addressing issues of elevated radionuclide activities in groundwater samples at the fenceline, that such contamination could result in significant errors in sampling results. This may also explain apparent elevated Pu-239,240 and Am-241 activities observed in well 1687, a lower hydrostratigraphic unit well which is believed to be isolated from the upper hydrostratigraphic unit.

Second, the sampling technique may contribute to error in the historical groundwater sampling results. The technique of sampling groundwater with a bailer is known to disturb the sediments both in the bottom cap of the well and in the surrounding matrix adjacent to the screened interval. The result is an increase in the apparent mobile solids concentration. The extremely high TSS values (up to 5,700 mg/L) observed for most groundwater samples with elevated radionuclide activities support the hypothesis that well installation and sampling techniques may be sources of error.

Relationship Between Baseflow Contribution and Surface-Water Activity

There is an apparent inverse correlation between groundwater flow contribution to GS10 and sample activity. A baseline flow rate of 0.07 cfs was estimated from the WY97 hydrograph for GS10. This value represents the average continuous flow at GS10 which may be attributable to continuous domestic leaks, discharge from footing drains in the IA, and/or groundwater seeps. Consequently, use of this value as an estimate of baseflow is a conservatively high approximation of groundwater contribution to surface-water flow at GS10. The estimated percent baseflow contribution during the sample collection at GS10 was calculated for each flow-paced carboy with Pu-239,240 and Am-241 activities greater than 0.15 pCi/L. The relationship between the baseline flow contribution and GS10 sample activities is presented in Figure 4-42.

The decreasing trend for activity with increasing baseline flow contribution suggests that groundwater is not the major source of radionuclide contamination at GS10. If groundwater were exclusively causing the elevated activities, a dilution effect from stormwater runoff would be expected. In other words, GS10 sample activity would increase with increasing percent baseline flow contribution.

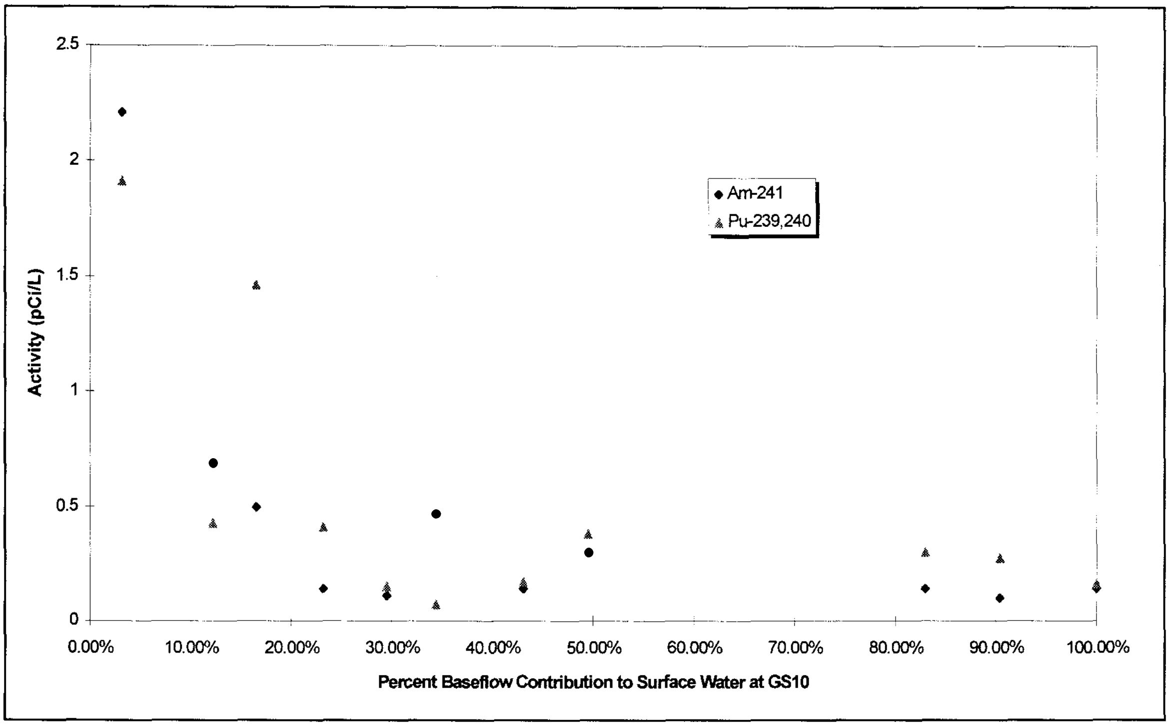

Figure 4-42. Relationship Between Baseline Flow Contribution and Flow-Paced Sample Activity at GS10.

Finally, high activity stormwater runoff samples collected at SW022 suggest that a significant proportion of the activity observed at GS10 is associated with overland flow. Since SW022 has no baseflow and receives no groundwater contribution, all flow at SW022 can be attributed to direct stormwater runoff. In fact, four of ten storm-event samples collected from SW022 in WY97 have Pu-239,240 values greater than 0.15 pCi/L. Further, the highest activity sample collected at SW022 (6.0 pCi/L Pu-239,240) was collected on the same start date as the GS10 sample with the highest activity.

5. PRELIMINARY DATA SUMMARY AND ANALYSIS FOR SW093

5.1. CONTINUATION OF RFCA MONITORING

Flow-paced sampling at SW093 and at the upstream tributary location GS32[31] (Figure 5-1) has continued as specified by the SW IMP. Forty-five composite samples have been collected at these locations since the

[31] GS32 samples runoff from the area draining B779 as a Performance Monitoring location in support of the B779 D&D. The configuration of the cmp makes flow measurement impossible without reconstruction. Therefore, samples are collected as storm-event time-paced composites of 15 grabs. To calculate load for this basin, discharge volume will have to be estimated based on the drainage area.

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start of WY97. Future analytical results from stations upstream of SW093 will be correlated with trends in the 30-day moving average values at SW093. This information may indicate water-quality patterns that could provide insight into the causes of the current values being measured at SW093.

5.2. WALK-DOWN OF DRAINAGE AREA

In response to the measurement of elevated levels of Pu at SW093, a walk-down was performed of the drainage area tributary to SW093 (Figure 5-1). The purpose of the walk-down was to visually identify conditions which may indicate source areas contributing to the elevated readings, and to site Source Location monitoring stations. Conditions which might indicate a potential source area are listed in Section 4.1.

The walk-down revealed no evidence of any man-made materials in the drainage pathways that indicate an uncontrolled release of contaminants. The drainage for SW093 is highly industrialized, and accordingly there is a multitude of possible sources of contamination. Many areas exhibited signs of high flows. Flows were large enough to breach stream banks. The erosion of the channel was typical of a "washout" that occurs during frequent periods of high flows due to the impervious areas in the drainage. Surrounding dirt roads and hillsides showed signs of runoff erosion, and many areas lacked vegetation to control erosion.

5.3. PRELIMINARY ASSESSMENT

The analytical results for the composite samples collected around the period have been verified. A review of historical monitoring data shows that these results are not unusual. In fact, the samples collected during WY97 are generally lower than those from previous years. It is not clear if this is due to the change in sampling protocols or an actual improvement in overall water quality. Storm-event samples collected at SW093 from WY93 through WY96 (under pre-RFCA storm-event sampling protocols) had an arithmetic average Pu-239,240 activity of 0.73 pCi/L with a maximum of 5.3 pCi/L (Figure 5-2). To the best of the Site's knowledge, during the recent elevated measurements, no off-normal conditions were experienced at any D&D, SNM stabilization or ER cleanup activities that could have affected water quality.

The drainage area for the surface-water monitoring location SW093 includes roughly 230 acres of the Site IA. Consequently, a variety of possible sources of radionuclide contamination could contribute to radionuclide activities at SW093. From the Site Historical Release Report[30], multiple Pu and general radionuclide-contaminated IHSSs were identified to be completely or partially within this drainage. Selected IHSSs are listed and described in Table 5-1.

Many other radionuclide IHSSs including PACs exist in the SW093 drainage. These IHSSs resulted from a variety of incidents and activities including spills from process waste lines and waste boxes, exposed storage of contaminated equipment following fires, burning of contaminated oil, release from unfiltered fume hoods, and overflow from a valve vault. In addition to recorded IHSSs, the SW093 drainage contains multiple exposed-dirt parking surfaces and roads common in the IA.

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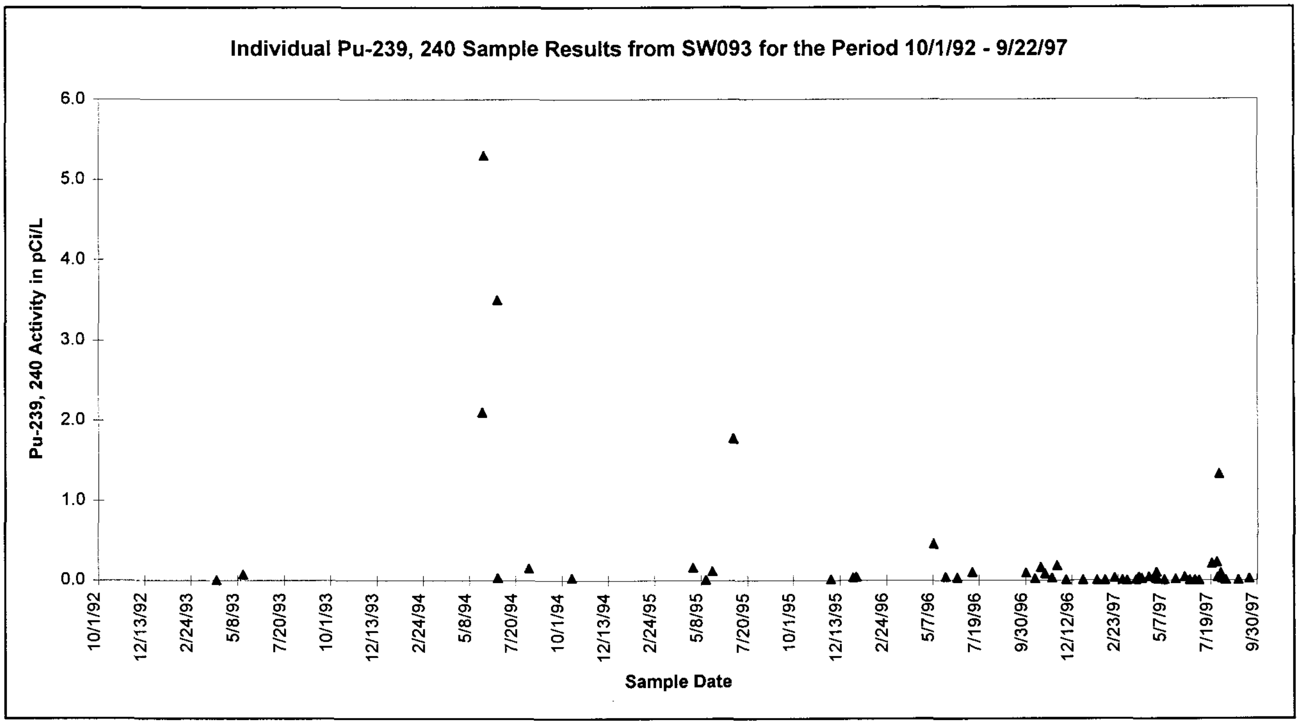

Figure 5-2. Individual Analytical Pu Results at SW093.

Considering the size of the basin and the large number of possible sources, specific identification of the source responsible for elevated radionuclide concentrations observed in the surface water at SW093 is difficult given the available data. Distributed contamination or multiple localized source areas could be responsible for the elevated measurements at SW093. Contributions from each source are also likely to be dependent not only on variables specific to the particular location, but also on the nature of the storm event, including intensity, duration, and localization of rainfall. A more thorough investigation will be included in Progress Report #3.

Table 5-1. Selected Pu IHSSs Located in the SW093 Drainage[30].

IHSS #	Location/Bldg.	Dates	Description
124, 125	B774; Tank 66	1953 - 1989	In July 1981, Tank 66 overflowed, spilling an estimated 500 gallons of liquid waste. On July 17, 1981, a tank in B774 about 3,300 gallons of process waste water overflowed and approximately 50 gallons ran onto the asphalt driveway. The Tank 66 spill had an alpha activity of 7.8 x 10^4 pCi/L. The process water from B774 was measured at 30,000 to 40,000 dpm/L Pu. The area was subsequently paved, but the contamination may not have been removed prior.
126.1,	B728 Process	1953 - 1984	These tanks overflowed several times prior to 1956, and

IHSS #	Location/Bldg.	Dates	Description
126.2	Waste Tanks		may have leaked during use. Liquid process wastes likely contained Pu.
127	B774	1957 - 1971	A low level waste line leaked at a joint. A soil sample from 1976 at a depth of 4 feet beside the leak area showed 1.83 dpm/g Pu.
128	Oil Burn Pit No.1	8/18/56	Two spots along the south side of the pit were shown to have meter readings of 500 and 750 cpm alpha. The pit was later backfilled with the residue in place. The residues were not removed prior to further construction in the area.
131	B776	6/64 and 5/69	An explosion resulted in an area of approx. 1,500 ft^2 being contaminated with Pu; some areas had activities greater than 200,000 dpm/67cm^2. Firefighting activities contaminated a 2,000 ft^2 area north of B776.
146.1 - 146.6	B774 Concrete Process Waste Tanks	Prior to 1956 - 1972	These tanks leaked and overflowed resulting in soil contamination with Pu, among other constituents.

6. A- AND B-SERIES DETENTION POND LOADING ANALYSIS

WY93 - WY97 Monitoring Data

Annual loads in micrograms are plotted in Figure 6-1. Influent sources to the ponds include those measured as SW093 (North Walnut Creek), GS10 (South Walnut Creek), and the WWTP (measured at B995). Unaccounted inflows to the ponds include direct runoff and precipitation from areas around the ponds, and inflows from SW091 (Figure 2-3). Loads from SW091 are approximately 1% of the load measured at SW093. All loads from the ponds are accounted for in the analysis. Therefore, influent loads are slightly underestimated, and actual removal efficiencies are also underestimated. For WY93 - WY96, the arithmetic average activity is multiplied by the associated total annual discharge volume, then converted to micrograms. For WY97, the activity for each flow-paced composite is multiplied by the associated discharge volume, then converted to micrograms and totaled.[32] The large load for WY94 can be attributed to high activities at SW093 (5 samples; average 2.217 pCi/L Pu).

[32] Available analytical from WY93 -WY97 by location: GS10, 10/25/92 - 9/22/97; SW093, 4/5/93 - 9/22/97; WWTP, 10/92 - 9/8/97; GS08, 3/23/94 - 5/12/97; GS11, 10/17/92 - 9/1/97.

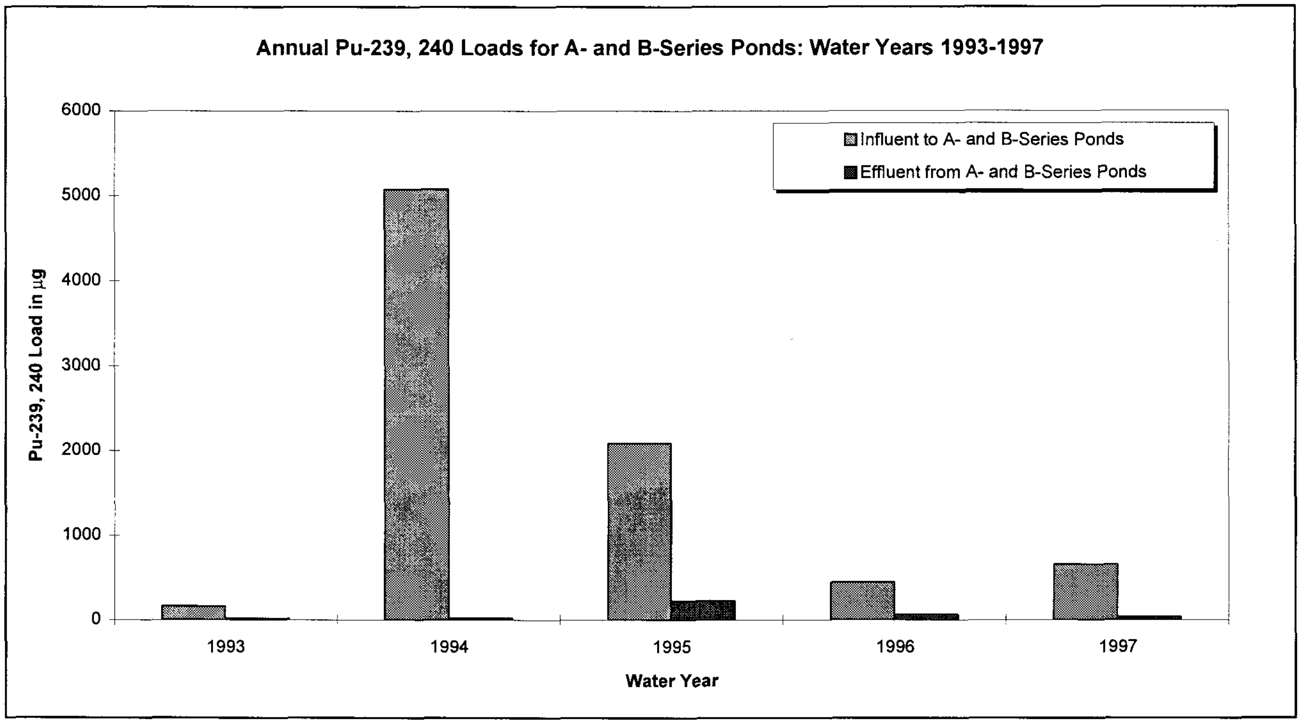

Figure 6-1. Annual Pu Loads for the A- and B-Series Ponds.

The annual removal efficiency of Pu load in the A- and B-Series ponds is plotted in Figure 6-2. For all years, removal efficiency is very high. This indicates the effectiveness of settling as a mechanism for removal of Pu from the water column. In fact, since actinide contamination at the Site appears to be low-level and widespread, actual removal of the contaminated soils would prove inefficient except for the most contaminated areas. Consequently, actinide removal at points of flow convergence (after the load is in the surface-water) through the use of flow-through settling ponds, coupled with watershed improvements to control erosion, may prove to be the preferred way to control actinide transport. This removal indicates that Pu was lost to the pond sediments and prevented from moving offsite.

Figure 6-3 shows the relative magnitude of loading to the A- and B-Series ponds from the three main tributaries. The small variation in WWTP loads is likely due to combine sewer inflows during wetter years.

Seasonal loads in micrograms are plotted in Figure 6-4. For all water years, the seasonal arithmetic average activity is multiplied by the associated average seasonal discharge volume, then converted to micrograms. It can be seen that the largest loads are during the seasons with the largest runoff volumes.

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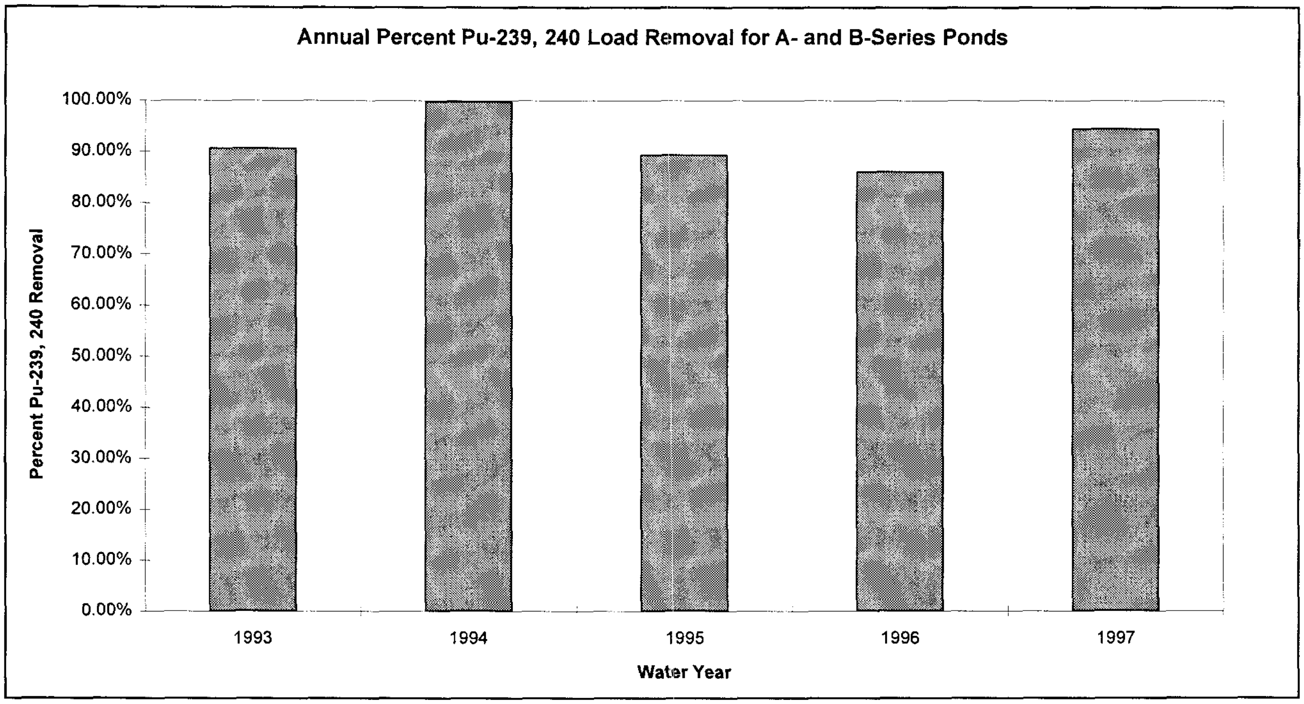

Figure 6-2. Annual Pu Removal Efficiency in the A- and B-Series Ponds.

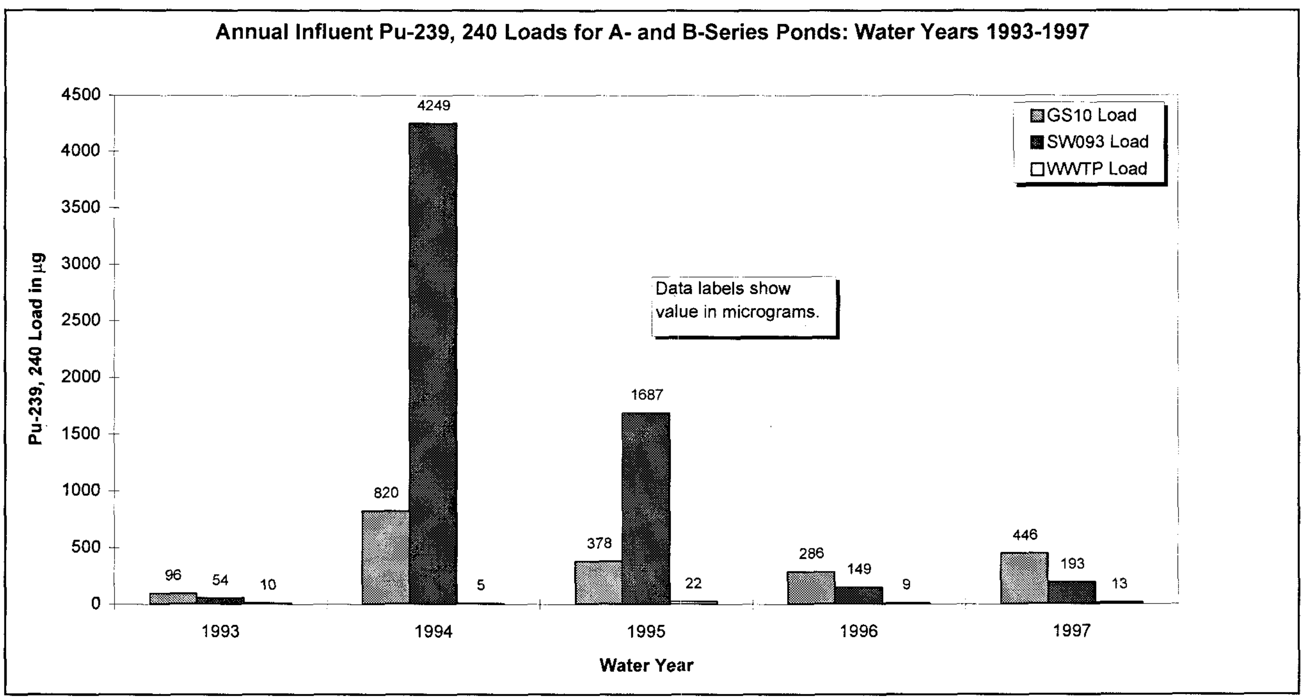

Figure 6-3. Influent Pu Loads to the A- and B-Series Ponds by Tributary Source.

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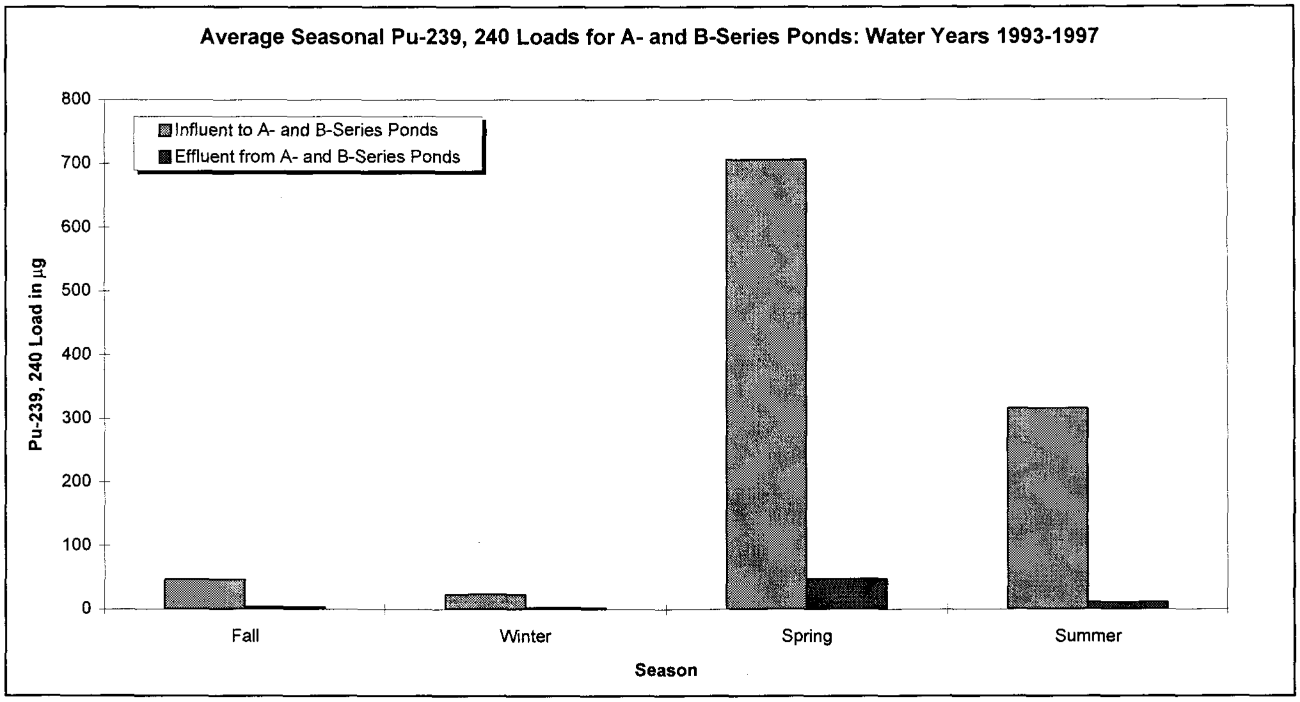

Figure 6-4. Average Seasonal Pu Loads for the A- and B-Series Ponds.

The seasonal removal efficiency of Pu load in the A- and B-Series ponds is plotted in Figure 6-5. Even though average residence time for contaminants in the ponds varies by season (batch discharge cycles are shorter in wet months), removal efficiency varies only slightly.

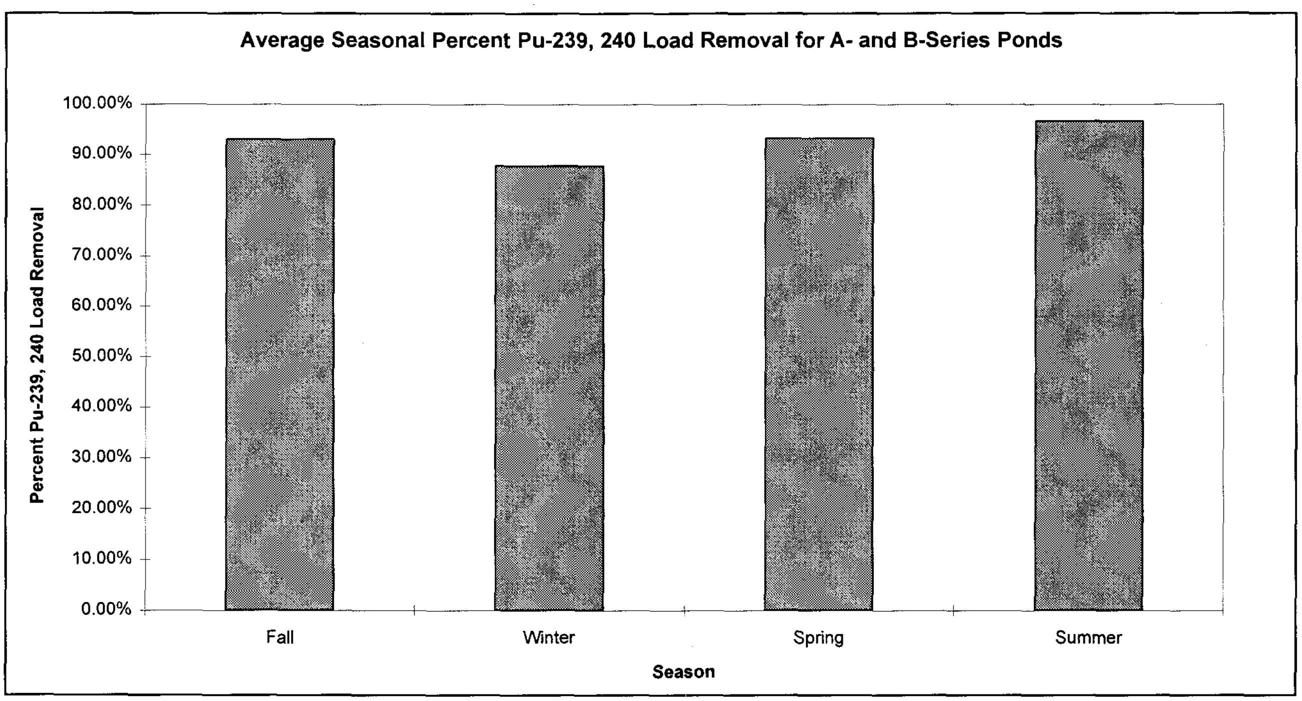

Figure 6-5. Average Seasonal Pu Removal Efficiency in the A- and B-Series Ponds.

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7. GS03 SOURCE LOCATION ANALYSIS: HYPOTHESES AND CONCLUSIONS

In Progress Report #1, a discussion of possible source hypotheses was included. The following section in this Progress Report #2, includes those hypotheses which are still considered possible causes of the elevated measurements at GS03. In the following section, a discussion of source hypotheses is presented. To date, a singular source for GS03 has not be identified. Information collected to date does not point to any singular conclusion. In fact, it is entirely possible that multiple sources and transport mechanisms are responsible for the elevated activities at GS03.

7.1. WIDESPREAD OR LOCALIZED SOIL AND SEDIMENT CONTAMINATION IN GS03 DRAINAGE

Site soils have a long history of contamination from historical releases. The section on historical releases (Section 3.7 in Progress Report #1) had identified numerous events from the Site's production era which introduced radioisotopes to Site drainages both as airborne and in surface-water runoff. Historic reports, the OU6 report, and a review of existing soil/sediment data indicate relatively low level, widespread Pu contamination of soils and sediments throughout the Walnut Creek drainage. Airborne contamination would result in more distributed contamination, with levels diminishing further from sources such as the 903 Pad. The movement of contaminated stream sediments could result in localized contaminated deposits or more evenly distributed contamination, depending on how active natural erosion processes are in Walnut Creek. The evaluation of historic soil and sediment data reconfirmed the low level soil and sediment Pu contamination through out the Walnut Creek drainage. However, no anomalous Pu source areas (i.e., those well in excess of background) were evident in within the tributary areas to GS03.

The OU6 report acknowledged that past production mission activities from 1952 through 1973 resulted in the release of significant amounts of Pu-contaminated surface waters to North and South Walnut Creeks, tributary to GS03. The B-Series pond reconstruction efforts from 1971 through 1973 were estimated to have re-mobilized several curies of Pu contaminated sediments, most of which would have been re-deposited in Pond B-1. Unknown amounts would have continued downstream and been deposited along South Walnut Creek, and subsequently Walnut Creek. As the drainage evolves over time, contaminated sediments could be buried, and then re-exposed at some later date. These deposits may be re-mobilized during periods of high flows which can erode stream bed and banks. These mobile contaminated deposits could then move through the drainage, and eventually be 'flushed' from the system, as the localized deposit of contaminated sediments is exhausted. Therefore, legacy contamination in the form of stream sediments could affect water quality intermittently, as indicated by the intermittent activities seen in GS03 samples (discussed in Section 3, Progress Report #1).

Soil and sediment activities for samples in the drainage are generally below 2 pCi/g. Activities in nearby non-tributary areas have been measured at up to 7 pCi/g. If an average activity of 2 pCi/g is assumed, and with a TSS in surface water of 100 mg/l (GS03 typically shows lower TSS values; other Site locations often show >1,000 mg/L), the expected activity would be 0.2 pCi/L. Given the soil activities in the drainage, the recent elevated activities at GS03 are possible.

Recent Walnut Creek sediment sample results from August 21, 1997 also show activities in this range of 0.0 to 1.0 pCi/g Pu (see Section 3.3 and Figure 3-20). The arithmetic activity for these samples was 0.27 pCi/g, with a maximum of 2.32 pCi/g.

Although wide-spread low level contamination is acknowledged for soils within the Walnut Creek drainage basin, the pond discharge conditions under which elevated Pu values observed at GS03 for which no precipitation occurred, are inconsistent with the theory of overland flow as the source of contamination. However, it is possible that soils are eroded, moved by overland flow, and re-deposited in the stream bed with each passing storm runoff event. These deposited sediments could then be re-suspended by baseflow to provide significant Pu activity in diminished water volumes (i.e., not diluted by storm runoff).

As noted in Section 3.2.3 of Progress Report #1, samples collected during A-4 discharges that showed significant runoff from precipitation which are indicative of overland flow (Figure 3-27, Progress Report #1), showed normal activities (0.022, 0.007 pCi/L). If runoff response from overland flow could be measured at GS03, then it is expected that any associated contaminated sediments would be available for sampling. Similarly, high runoff during the period April 24-29, 1997 (up to approximately 45 cfs at GS03), showed low levels of Pu.

7.2. LOCALIZED CONTAMINATION AT GS03 SAMPLING LOCATION

The Historical Release Report supports the hypothesis that localized contamination exists at GS03, specifically in the flume pond and the surrounding soils/sediments. The area was identified as an IHSS due to past radioactive releases to the A-series and B-series drainages (as discussed in Section 3.7, Progress Report #1), and the soil in the area is potentially contaminated with radionuclides. The construction of the dam and flumes at GS03 involved movement of the soil. It is unknown if these materials were simply moved from the surrounding area (potentially contaminated), borrowed from some other area (potentially contaminated or uncontaminated), or brought in clean from offsite. A storm event on May 16-17, 1995 caused the level of the flume pond to top the dam, and erosion took place on the dam face around the flumes. Potentially contaminated soil was exposed, and as further erosion took place over time, portions of the soil may be sloughing off in the water at the outlet. Since the sampler intake sits just below the flumes, it is possible that periodic erosion would result in the intermittent occurrence of elevated levels of Pu and Am in samples at GS03.

The fact that this pond has been ‘re-worked’ in the past, coupled with the intermittent nature of the elevated measurements at GS03, and the recent erosion (flood of May 1995) of the dam structure itself, points toward the dam materials as a possible source of contamination. Accordingly, soil samples were collected from the eroded dam materials immediately north and south of the GS03 flume on September 9, 1997. However, non-validated results show low levels of soil activity (Table 7-1).

Table 7-1. Soil Activity from GS03 Flume Pond Dam Materials.

Location Code	Pu-239,240 pCi/g	Pu Error pCi/g
17197; North	0.023	0.025
17297; South	0.071	0.049

Additionally, a synoptic sampling event was performed along Walnut Creek between Pond A-4 and GS03, in order to determine spatial variability in water quality. Samples were collected both immediately upstream and downstream of the flumes. The upstream sample activity was -0.003 ± .01 pCi/L, while the downstream sample activity of 0.042 ± 0.0 pCi/L. Although this change is negligible, the turbulent action of the water downstream of the flume, at the sampling point, may stir-up bottom sediments that did not pass through the flume, which were subsequently collected by the sampler. Accordingly, Site personnel will be moving the sample intake to a sampling trough attached to the end of the flume structure which will collect only water and TSS which passed through the flume.

7.3. MOBILIZATION OF SEDIMENTS IN POND AT GS03

The hypothesis that the GS03 flume pond sediments are a potential source of elevated radionuclide levels at GS03 is supported by the fact that the source is available under all flow regimes. Even during periods of low flow, groundwater infiltration through the pond sediments provides a source of mobility for the sediments. During periods of high flow, disturbance of the sediments could occur as increased inflow takes place. However, when the assumption is made that Pu/Am activity is associated with the sediments, a correlation can be made between the concentration of TSS and the level of activity that challenges this theory. Using a range of TSS values from 1.3 - 130 mg/L (a magnitude of difference from an actual measured value of 13 mg/L), and an approximate measured value of Pu of 0.1 pCi/g for sediment samples taken in the GS03 flume pond, the calculated value of Pu in water would be 0.00013 - 0.013 pCi/L. A result in this range is much lower than the elevated levels measured at GS03.

Three pond bottom sediment samples were taken in the flume pond, which provided results of recent Pu and Am levels in the pond sediments (Table 3-6; locations 15197, 15297, 15397 in Figure 3-18). Activities were 0.141, 0.045, and 0.139 pCi/g Pu. These values are of similar magnitude to other soil/sediment samples in the drainage. In addition, a synoptic sampling event (sampling the same "plug" of water at different locations) was performed along Walnut Creek between Pond A-4 and GS03, in order to determine spatial variability in water quality. Locations included the inlet to the flume pond (location 15597 in Figure 3-15), and the outlet from the flume pond just upstream of the flumes (location 17097 in Figure 3-15). These locations show activities of -0.002 ± 0.008 pCi/L and -0.003 ± 0.01 pCi/L. These results indicate that no loading occurred due to the flume pond sediments during this sampling event.

7.4. TRIBUTARY SURFACE-WATER SOURCE

Another hypothesis to address is that radionuclide contamination of surface water observed at GS03 originated from surface-water tributaries to the Walnut Creek drainage. Two noteworthy tributaries, McKay Ditch and No Name Gulch, converge with Walnut Creek between the Terminal Ponds and GS03.

Several facts suggest that contaminated water sampled at GS03 did not originate as contaminated water in McKay Ditch and No Name Gulch. First, the high Pu activity recorded from the composite sample started on May 15, 1997 was collected during conditions of low flows. The flow rates observed at GS03 during collection of this sample (on the order of hundredths of a cfs) were likely much greater than any flow rates in the contributing tributaries. Further, No Name Gulch has a detention pond (possibly an old agricultural reservoir), which detains some runoff in No Name Gulch, dramatically increasing the amount of precipitation required to produce flows reaching Walnut Creek. Second, 2 composite samples collected at GS03 showed elevated levels of Pu, despite the fact that there was no significant precipitation during the sampling period to produce runoff in the major tributaries. Finally, composite samples taken at GS03, encompassing the significant runoff event of April 25-29, 1997 yielded no elevated radionuclide activities. Peak flow rates reached approximately 45 cfs at GS03 during the period April 24-29, 1997, indicating that that tributaries likely contributed high flows correspondingly. If surface water from McKay Ditch and No Name Gulch were carrying activity to GS03, it would be expected that levels of activity would correlate with runoff.

Though there is significant evidence to suggest that the contaminated water observed at GS03 did not originate as contaminated water in the major tributaries, it remains possible that the tributaries contribute contamination in the form of solids to the Walnut Creek drainage. However, results from the August 21, 1997 sediment sampling along Walnut Creek (see Section 3.3) do not indicate significant spatial trends in sediment activity that show contaminated sediment loads from these tributaries. Also, two new Source Location monitoring stations were installed on these tributaries just upstream from their confluences with Walnut Creek (GS33 on No Name Gulch and GS35 on the McKay Ditch; Figure 2-3). These locations are equipped to collect continuous flow-paced composite samples and gage stream flow which will be used in loading calculations. To date, both GS33 and GS35 have collected two samples.

Additionally, GS34 will be installed on Walnut Creek just upstream of the McKay Ditch confluence to provide increased loading resolution (see Section 9.3.4).

7.5. 'HOT PARTICLES'

It is possible that the recent elevated measurements at GS03 are an indication of the existing variability of actinide in surface water. Previous sampling protocols may not have accurately characterized the true variability of surface-water activities. Current sampling protocols (see discussion in Section 6.2.4 in Progress Report #1) have dramatically increased the number of grab samples collected at GS03.

The change in sampling protocol brings into question whether the recent 'elevated' measurements at GS03 and GS10 are actually deviations from the norm. In previous years, perhaps 50-100 grabs were pulled at these locations. Under the continuous flow-paced protocols, up to 2500 grabs may be pulled in a given year depending on location (over 1267 grabs were collected at GS03 in WY97). Assuming that activities in surface water are highly variable, due to either 'hot particles' or some other physiochemical mechanism, than an increased number of grabs would increase the probability of collecting water with relatively high activities. Consultation with the Actinide Migration Study Specialist and the DQO Statisticians is in progress regarding these sampling protocol effects. Results and analysis will be made available in subsequent reports.

7.6. POTENTIAL ISSUES WITH LABORATORY RESULTS

Another hypothesis concerns possible issues with the quality of analytical laboratory results received from GS03 as well as other RFCA locations. Variations in analytical data from what has been historically observed at GS03 could be attributed to many factors. These include changes in sample collection protocols (flow paced composites vs. grabs as previously described), use of many newly sub-contracted analytical labs (to date, 3 sub-contracted labs have been used versus one onsite lab) and general analytical variability for radiochemistry samples at or near the level of detection. All sub-contracted labs are required to perform to the same Statement of Work (SOW) and should produce the same quality data. This is one of the more likely sources of sample result variability as each laboratory used may introduce it's own variability within the radiochemistry analysis process.

These issues will continue to be investigated and if additional information is encountered, updates will be provided in subsequent progress reports.

8. GS10 SOURCE LOCATION ANALYSIS: HYPOTHESES AND CONCLUSIONS

In the following section, a discussion of source hypotheses for GS10 is presented. To date, a singular source for GS10 can not be identified. Information collected to date does not point to any singular conclusion. In fact, it is likely that multiple sources and transport mechanisms are responsible for the elevated activities at GS10.

8.1. WIDESPREAD OR LOCALIZED SOIL AND SEDIMENT CONTAMINATION IN GS10 DRAINAGE

Site sediments have a long history of contamination from historical releases. The section on historical releases (see Section 4.7) identifies numerous events from the Site's production era which introduced radioisotopes to Site drainages both as airborne and in surface-water runoff. In Section 4, historic reports and a review of existing soil/sediment data indicate widespread Pu contamination of soils and sediments throughout the GS10 drainage. Airborne contamination would result in more distributed contamination, with levels diminishing further from sources such as the 903 Pad. The movement of contaminated soils and sediments in runoff could result in localized contaminated deposits or more evenly distributed contamination, depending on how active natural erosion processes are in the GS10 drainage. The GS10 drainage includes numerous Pu source areas.

Soil and sediment activities for samples in the drainage show a range of nearly 7 orders of magnitude (see Section 4.6). The highest values are associated with soils under the 903 Pad, and therefore do not come in contact with runoff. The maximum TSS measured to date at GS10 is 1,500 mg/L. At these levels of TSS

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and assuming uniform suspension of soils, a soil with 0.1 pCi/g could yield activities of 0.15 pCi/L. Given the soil activities in the drainage, the recent elevated activities at GS10 are possible.

Section 4.2 shows that the GS10 sub-basins which are currently monitored all contribute Pu load to GS10, further supporting the hypothesis of multiple or widespread source areas. Additionally, the apparent relationship between TSS, precipitation, and Pu activity supports this hypothesis. It is also possible that soils are eroded, moved by overland flow, and re-deposited in ditches with each passing storm runoff event. These deposited sediments could then be re-suspended by subsequent events to provide Pu activity at GS10.

Data collected from the Source Location monitoring locations (see Section 9.3.4) will further determine the proportions of Pu load that each monitored sub-basin may be contributing. If a certain sub-basin is determined to be contributing a significant proportion of the load at GS10, watershed improvements can be used to mitigate further transport. These types of watershed improvements have been demonstrated for other locations around the Site, specifically at GS27 (see Section 4.2 and 4.3).

8.2. LOCALIZED CONTAMINATION NEAR GS10 SAMPLING LOCATION

The Historical Release Report supports the hypothesis that localized contamination exists in the drainage immediately upstream of GS10, specifically the sediments in the stream reach between B991 and GS10. The area was identified in the Historical Release Report due to past radioactive releases to the B-series drainages (as discussed in Section 4.7), and the soil in the area is potentially contaminated with radionuclides.

Data collected from the Source Location monitoring locations (see Section 9.3.4) will further determine the proportions of Pu load that each monitored sub-basins may be contributing. If the sub-basins upstream from these areas (around B991 and 995) are shown to be contributing a small proportion of the load at GS10, then this area may be contributing a significant proportion of the load. Sediment samples could then be collected to evaluate the sediments in this stream reach.

8.3. GROUNDWATER SOURCE

One hypothesis to explain the elevated levels of Pu and Am observed at GS10 is groundwater contamination of surface water. This hypothesis is supported by the existence of groundwater seeps at the base of the Rocky Flats Alluvium and the proximity of the 903 Pad. Most of the available evidence, however, does not support this hypothesis.

As discussed in Section 4.8, wells within the GS10 drainage currently sampled for radionuclides exhibit no elevated activities or trends with time. Recent data, however is unavailable for consideration due to delays with RFSWD. Examination of the historical record revealed samples from eight wells within the GS10 drainage exceeding 0.15 pCi/L Am or Pu. These data, however, are questionable due to limitations of well installation and sampling techniques as supported by extremely high TSS values.

The relationship between baseflow contribution and surface-water activity at GS10 further disputes the hypothesis that groundwater is a primary source of radionuclide contamination at GS10. To begin, there is an apparent inverse correlation between groundwater flow contribution to GS10 and sample activity. Further, high activity stormwater samples collected at SW022 which correspond to high activity samples at GS10 suggest that a significant portion of the contamination observed at GS10 is associated with surface-water runoff. Since SW022 has no baseflow and receives no groundwater contribution, all flow at SW022 can be attributed to direct stormwater runoff.

In short, the available evidence does not support the hypothesis that groundwater seeps are a major source of radionuclide contamination of surface water at GS10. However, considering the proximity and history of the 903 Pad, continued and possibly expanded monitoring of groundwater between GS10 and the 903 Pad may be useful. Results of groundwater samples recently collected within the GS10 drainage (Table 4-9) will be reported as soon as they become available.

8.4. TRIBUTARY SURFACE-WATER SOURCE

Another hypothesis to address is that radionuclide contamination of surface water observed at GS10 originated from surface water tributary to GS10. Section 4.2 shows that the GS10 sub-basins which are currently monitored all contribute Pu load to GS10, supporting the hypothesis that tributary surface water is carrying load toward GS10. Data collected from the Source Location monitoring locations (see Section 9.3.4) will further determine the proportions of surface-water Pu load that each monitored sub-basin may be contributing. If a certain sub-basin is determined to be contributing a significant proportion of the load at GS10, watershed improvements can be used to mitigate further transport in surface water. These types of watershed improvements have been demonstrated for other locations around the Site, specifically at GS27 (see Section 4.2).

9. PROGRAM STATUS: ISSUES AND HIGHLIGHTS

9.1. REPORTING

Reporting of monitoring information is required by the SW IMP, RFCA, and Site administrative systems. This reporting requires notification of organizations such as Site contractors and departments, Kaiser-Hill, DOE, regulators, cities, and stakeholders. To facilitate the orderly dissemination of information, these reporting protocols are being streamlined and standardized.

Monitoring and reporting of water quality continues sitewide and in Walnut Creek. EPA has agreed to incorporate all Walnut Creek POCs and POEs in the ongoing Source Evaluation. Weekly status briefs continue to be issued to provide stakeholder updates. Important key findings are reported in 'flash briefs' as information becomes available.

9.2. SAMPLING AND ANALYSIS

9.2.1. Verification of Elevated Analytical Results

Since Progress Report #1 all data returned to date from the analytical labs has met the required QA/QC criteria and no re-runs for questionable data have been requested.

9.2.2. Analytical Turn-Around-Times

The Site continues to request an accelerated sample turnaround for POC location GS03, however, in practice, the requested turnaround is not routinely met. Discussions with the Analytical Projects Office, Kaiser-Hill, are in progress to identify concerns and problems with sample turnaround. No FY98 funding has been identified to provide accelerated turnaround for the other 4 POC locations, however this continues to be evaluated.

9.2.3. Analytical Data Validation

Funding issues concerning 100% data validation for all POCs also continue to be evaluated. As of the publication of this progress report, appropriate documentation to request funding for data validation is being completed and submitted for approval to Kaiser-Hill and DOE.

9.3. AUTOMATED SURFACE-WATER MONITORING

9.3.1. Continuous Flow-Paced Sampling

As part of the source evaluation, and in accordance with RFCA, continuous flow-paced and storm event sampling has continued as specified in the SW IMP for North, South, and Lower Walnut Creek. Start and completion dates of samples for which analytical data has not yet been returned from the laboratory are presented in Table 9-1. No samples have been collected at GS08 since May 12, 1997.

Upon receipt of laboratory results, 30-day moving average calculations will be updated as appropriate, and data will be included in Source Evaluation Progress Report #3.

As reported in Progress Report #1, laboratories have been instructed to run TSS analysis on any samples which have not, by virtue of the sample collection duration, exceeded the maximum hold time of 7 days[33]. Collection of TSS information will aid in the determination of transport mechanisms for Pu, which tends to form strong associations with solids.

[33] TSS is not analyzed at Terminal Pond discharge points GS11 and GS08. TSS values at these locations are less than detection under normal discharge conditions. During emergency conditions where the Terminal Ponds would be discharged prior to the analysis of pre-discharge samples, TSS would be analyzed.

9.3.2. POC Gaging Station Upgrades

POC gaging stations in Walnut Creek and Woman Creek have been evaluated for winter freeze protection including outfitting with submersible heat tape/coils or other modifications to reduce the possibility of sample intake line freezing and the attendant gaps in sample collection. This will allow sampling equipment to more reliably collect water samples during extreme cold weather.

Table 9-1. Log of Recent Walnut Creek Samples.

Location	Gaging Station	Sample Start Date	Sample Collection Date
Lower Walnut Creek	GS03	9/4/97	9/9/97
		9/9/97	9/24/97
		9/24/97	9/27/97
		9/27/97	10/1/97
		10/1/97	10/3/97
		10/3/97	10/5/97
		10/5/97	10/8/97
		10/8/97	10/10/97
		10/10/97	10/27/97
		10/27/97	10/30/97
	GS08	9/24/97	9/26/97
		9/26/97	9/30/97
	GS11	9/1/97	9/4/97
		9/4/97	9/8/97
		10/1/97	10/5/97
		10/5/97	10/8/97
		10/8/97	10/10/97
North Walnut Creek	GS10	9/23/97	10/2/97
		10/2/97	10/8/97
		10/8/97	10/13/97
		10/13/97	10/22/97
		10/22/97	10/24/97
		10/24/97	10/29/97
	GS27	10/24/97	10/24/97
	SW022	10/12/97	10/12/97
South Walnut Creek	SW093	9/23/97	10/6/97
		10/6/97	10/13/97
		10/13/97	10/23/97
		10/23/97	10/27/97

Heat tape systems that have been chosen require either 110v or 220v AC line power to provide adequate temperature regulation. The vendors that have been consulted have not recommended an attempt to construct DC freeze-protection systems. AC line power currently exists at some sampling locations, but has proven to be unreliable, often failing during inclement weather. Therefore, AC supplies will need to be

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upgraded at most locations, while other locations will require complete construction of power lines to the gaging station.

WM&T personnel are currently consulting with RMRS engineering staff to provide an accurate cost estimate on the modification, and or construction of reliable AC line power at POC monitoring locations. The POC upgrade project is currently under-funded, but negotiations are underway between RMRS and KH to secure additional funding. Once the project is funded, contracts will be awarded to complete the installation of AC line power and freeze protection for sampler operations.

On Nov. 4th , WM&T and engineering personnel performed a walk-down of the POC locations to initiate the development of a cost estimate. Engineering personnel will provide to WM&T staff an estimate on the design phase of the project in 5 to 10 working days. WM&T and engineering staff will then perform a second walk-down of the POC locations with RMRS cost estimators to determine the funding required to complete the construction phase of the project.

In addition to AC line power, WM&T staff are working on a cost estimate to upgrade the primary measuring device at GS01. The 9" Parshall flume works for nominal flow measurements, but is inadequate for substantial flows due to major run off from storms and snow melt. Once the project is funded, contracts will be let to complete the upgrade to an adequate measuring device for all anticipated surface-water flows.

In September, upgrades were completed at GS03 to stabilize the primary measuring device. The 6" and 36" Parshall flumes were reinforced with packing material to minimize erosion and ensure a tight seal.

9.3.3. Increase in Baseflow Sample Frequency at GS03

The SW IMP has determined through the DQO process that collection of one composite sample at gaging station GS03 in the intervening period between Terminal Pond discharges is adequate to characterize baseflow leaving the Site. To accomplish this, samplers are paced based on historical records of baseflow and runoff to collect 2.5 times the minimum required for volume for laboratory analyses, giving an acceptable range of error in flow prediction of 60%. In the event that historical records overestimate the baseflow between discharges by more than 60%, and an insufficient volume of water is collected to complete the required analyses, the IMP specifies that the collected sample may be recorded as NSQ and discarded. To date during WY97, three NSQ samples have been discarded. As a result, a small fraction of the total surface water leaving the Site via GS03 is uncharacterized, confounding loading and 30-day average calculations as well as source evaluation investigations.

To further minimize the number of NSQ samples, WM&T Group has elected to collect two composite samples during the intervening period between Terminal Pond discharges. To accomplish this, samplers are paced based on historical records of baseflow and runoff to collect two samples with 2.5 times the minimum required volume for laboratory analyses, effectively increasing the acceptable range of error in flow prediction from 60% to 80%. This procedural change was implemented on September 9, 1997, and no NSQ samples have been collected as of November 7, 1997. Also three non-terminal pond discharge samples have been collected for the periods September 9-24, 1997, October 10-27, 1997, and October 27-30, 1997.

9.3.4. Installation of Source Location Monitoring Locations

Tributary to GS03

Two new gaging stations, GS33 and GS35, have been installed upstream from GS03 in an effort to better characterize contributions to Walnut Creek from the major tributary subdrainages (see Figure 2-3). These locations are installed to support the Source Location Decision, as specified in the SW IMP. Collection of flow record and continuous flow-paced samples for laboratory analysis at these locations will facilitate loading calculations to determine which tributaries may be sources of contamination.

GS33 is located on No Name Gulch just above the confluence of No Name Gulch and Walnut Creek. Construction and instrumentation of GS33 was completed on September 15, 1997, and the location was immediately operational. The flow measurement device at GS33 is a 9.5-inch Parshall flume, capable of measuring flow rates up to 4.4 cfs. GS35 is located on McKay Ditch just above the confluence of McKay Ditch and Walnut Creek. Construction and instrumentation of GS35 was completed on September 18, 1997, and the location was immediately operational. The flow measurement device at GS35 is a 3-foot contracted rectangular weir, capable of measuring flow rates up to 18.4 cfs.

Both locations are equipped with electronic flow meters to collect 5- and 15-minute flow record and automated samplers programmed to collect continuous flow-paced composite samples. Power at each location is solar with battery backup. Operational protocols currently applied to maintain all RFCA surface-water monitoring locations will also be applied to GS33 and GS35. To date two composite samples have been collected from each location.

A third Source Location monitoring location will be installed during the first quarter of FY98. This gaging station, GS34, will be located on Walnut Creek, just upstream of the confluence of McKay Ditch (see Figure 2-3). This location will consist of a 1.5-foot Parshall flume equipped with the same flow measurement and sampling capabilities as GS33 and GS35.

Tributary to GS10

Three Source Location monitoring locations will be initially installed to continuously sample surface-water flows to further delineate the GS10 tributaries (Figure 9-1). Monitoring locations were determined based on the analysis of existing data to further scrutinize the GS10 drainage basin. These locations will employ flow control devices (e.g. flumes, weirs) and continuous flow-paced and/or synoptic storm-event sampling to calculate mass transport to determine which sub-drainages may be contributing contaminants. Water-quality information from sub-drainages may also indicate the degree to which source areas are localized or wide-spread. Additional monitoring locations may be installed to support the ongoing source evaluations. These locations will be targeted to further determine any localized source areas.

A concrete spillway east of the 700 Area on South Walnut Creek will be instrumented with a 1-foot Parshall flume. This location will monitor runoff from the areas around B776, 777, 778, 707, and 750. The small ditch north of the 904 Pad will be instrumented with a 1-foot H-flume. This location will monitor runoff from the areas around the 903 Pad, 904 Pad, and a portion of the Contractor Yard. Central Avenue Ditch just east of the corrugated metal pipe under 8th Street will be instrumented with a 9.5-inch Parshall flume. This location will monitor runoff downstream of the 100, 400, and 600 Areas, but be upstream of the 800 Area runoff contributions.

Tributary to SW093

Three Source Location monitoring locations will be initially installed to continuously sample surface-water flows to further delineate the SW093 tributaries (Figure 9-1). Also, SW118 will be upgraded with an automatic sampler. Monitoring locations were determined based on the analysis of existing data to further scrutinize the SW093 drainage basin. These locations will employ flow control devices (e.g. flumes, weirs) and continuous flow-paced and/or synoptic storm-event sampling to calculate mass transport to determine which sub-drainages may be contributing contaminants. Water-quality information from sub-drainages may also indicate the degree to which source areas are localized or wide-spread. Additional monitoring locations may be installed to support the ongoing source evaluations. These locations will be targeted to further determine any localized source areas.

SW118 will monitor runoff from areas north of the PA and portions of the 300 Area. A 1-foot H-flume will be installed in the ditch north of the Solar Ponds along the PA Perimeter Road, just west of GS32. This location will monitor runoff from the areas around B774, 771, 371, 374, 776, and 777. A 1-foot Parshall flume will be installed in the gully east of B374 and upstream from the Metrology Lab. This location will monitor runoff from the areas around B559, 776, 566, 371, and 374. A 9.5-inch Parshall flume or rectangular weir will be installed in the small ditch west of Tank 231B. This location will monitor runoff from portions of the 100, 300, and 500 Areas.

9.4. SOIL AND SEDIMENT SAMPLING

9.4.1. New Locations Tributary to GS10 and SW093

Soil and sediment samples will be collected from the drainage tributary to GS10. Locations of these samples will be determined based on the analysis of new and existing data. Particular attention will be given to the results of the loading analysis for existing stations and proposed Source Location stations (see Section 9.3.4). These sediment/soil locations will be sited to indicate spatial activity variations and to fill any gaps in existing data. Sediment/soil activities from the drainage pathways tributary to GS10 and SW093 will be analyzed for spatial variability which may indicate the location of a source area. Summary statistics for these new values will be evaluated against historical results in the area to indicate changes. Additionally, these values will be compared to surface-water radionuclide activities in a loading context.

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Additional soil and sediment sampling is anticipated in support of the ongoing source evaluations. These samples will be targeted to further define any localized source areas.

9.5. GROUNDWATER SAMPLING

Additional groundwater samples may be collected from existing or new wells with need based on the ongoing source evaluations. These samples will be targeted to further determine any localized source areas.

9.6. ACTINIDE MIGRATION STUDIES

As discussed previously in Progress Report #1, the Site has undertaken comprehensive multi-year Actinide Migration Studies to improve understanding of the behavior and transport of Pu, Am, and U in the environment. This understanding of actinide migration will provide insight into the nature and movement of potential sources at RFETS.

In FY97 the Actinide Migration Studies group has collected and analyzed soil and sediment samples for plutonium loading and by sequential extraction techniques designed to uncover plutonium's associations with chemically identifiable soil fractions. This information will be used in Site cleanup in evaluating long-term protectiveness of soil action levels on surface water and on long-term surface-water compliance at Site closure. Preliminary results of this group have been presented elsewhere and reported in our earlier report.

9.6.1. Summary of Actinide Migration Study Results To-Date

Preliminary results of the Actinide Migration Study investigation have been reported in a stakeholder meeting on August 20, 1997 and most recently in a technical conference of the Advisory Group on October 27-28, 1997. To summarize the major findings potentially relevant to this source evaluation:

- Homogenized sediment cores from Pond B-5 showed Pu activities between 0.09 and 0.57 pCi/g;
- Pond B-5 sediment show Pu loadings that vary slightly with depth between 0 and 15 cm. Results varied from 0.27 pCi(Pu)/g to 1.5 pCi(Pu)/g with the uppermost sediments showing a 0.58 pCi(Pu)/g; and
- Methods used have a PQL of approximately 0.05 pCi/g.

Soils from the 903 Pad and Lip Area were also evaluated using selective chemical extraction methods which test plutonium's association with major, chemically distinguishable soil fractions — namely, exchangeable, carbonate, sesquioxide, organic, and residual fractions. The following findings are potentially relevant to this source evaluation:

- Organic and sesquioxide fractions show the greatest pCi(Pu)/g loadings with organic fractions showing loadings approaching 100 pCi(Pu)/g; and
- Loadings (pCi (Pu) per gram soil) in the various soil fractions show a nearly three order-of-magnitude range in activity loading within any particular sample;

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- At the 903 Pad and Lip Area, Pu in soils occurs in association with the "organic" soil fraction; and
- The methodology and protocols is limited to the sample background value of approximately 0.05 pCi(Pu)/g.

More recent significant conclusions from the FY97 Actinide Migration Study which are relevant to the Walnut Creek source investigation are:

- Partition coefficients for soil/sediment-water system (ranging from 10^4 to 10^5 L/kg) indicate that Pu is strongly bound to particulates, and is likely mobilized by physical transport mechanisms and not by dissolution under normal conditions;
- Phase speciation indicates that the Pu associated with organic and residual fractions may be relatively mobile under certain environmental conditions since it associates with particles; and
- Pond inventory from sediment cores indicates an estimated annual-average deposition of 0.1 mCi(Pu)/year is delivered to Pond B-5.

9.6.2. Consultation with Actinide Migration Advisory Group

The Walnut Creek Source Evaluation task team has consulted with the Actinide Migration Studies Advisory Group and provided the latest source-evaluation information (that available through the October 28, 1997) in the presentations and discussions at the FY97 Results Discussion and Model Development Meeting, October 27-28, 1997.

Additional source-investigation tasks which were recommended by Actinide Migration experts (and discussed in Progress Report #1) are planned or remain under consideration by the Source Evaluation task force. These are further evaluated in Table 9-2.

9.6.3. Actinide Migration Study Scope of Work for FY98

The FY98 scope of work for the Actinide Migration Study effort includes several elements applicable to this source investigation:

- Complete phase speciation studies and determine chemical speciation of Pu;
- Analyze surface-water samples to provide physical and chemical speciation;
- Complete surface-water mass loading;
- Complete partition coefficient studies designed to bound the variability range of partition coefficients applicable to the Site; and
- Complete an erosion and physical transport analysis using the watershed model.

Table 9-2. Remaining Actinide Migration Study Recommendations

Recommendation	Actions Taken to Date / Status
1. Collect TSS samples with normal sampling.	TSS samples are planned for grab samples taken to support this investigation; the use of regular automated sampling to collect TSS samples is frustrated by the hold time limitation of 7 days.
2. Calculate/trend Pu-to-Am ratios for the elevated samples versus historical results.	Planned for FY98.
3. Examine relative analytical errors including counting, MDA, etc. (taking into account propagation of errors) to determine significance exceedance Evaluate minimum detectable activity and analytical uncertainty to determine their impact on compliance.	Detection limit issues and variability are being considered.
4. Determine Pu-240/Pu-239 isotopic ratios on exceedance planchets to assist in identifying source(s)	Planchets are preserved awaiting isotopic assay in FY98.
5. With 4 individual samples returned with >0.15 pCi/L (Pu) consider the importance of "bunching" or fortuitous grouping (non-randomness) and its impact on compliance.	Statistical methods will be applied to the data.
6. Perform TSS, total organic carbon (TOC), and filtered/unfiltered radiochemistry as needed to address particle size of contaminant.	There may be technical limitations placed by automated sampling method and will require special grab sampling. Sampling and analyses will be planned to avoid hold-time and sampling-protocol issues (e.g., plastic carboys used in the current automated sampling program cannot be used for TOC samples).

9.7. SUMMARY

The Site is in close communication with regulators, cities, and stakeholders regarding the status of source evaluations and monitoring programs. Table 9-3 is a recent Weekly Project Status Report (November 3, 1997) issued by the Site.

The Source Evaluation Progress Report #3 to be submitted on December 31, 1997 will include the assessment of current existing monitoring data for SW093, and any new data from GS03 and GS10. The following will be included in Progress Report #3 for Walnut Creek:

- Preliminary conclusions and hypotheses for source location(s) with supporting and non-supporting information, including preliminary results on source location;
- Results and analysis of ongoing RFCA monitoring;
- An assessment of existing monitoring data for SW093;
- An assessment and incorporation of available new data for GS03 and GS10;

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- An evaluation of the effects that watershed improvements may have had on water quality at GS03 and GS10;
- An identification and quantification of downstream effects from any identified source;
- An identification of data gaps and uncertainties in the source evaluation process with suggested modifications (if any) to the Actinide Migration Study Workscope and the SW IMP; and
- A summary and of current Actinide Migration Study findings with cross-links to source evaluations; and
- A summary of the status for sampling and operational modifications.

Table 9-3. Weekly Project Status Report: November 3, 1997.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
1	Verify laboratory results and 30-day average calculations for the recent (May-June 1997) GS03 water quality measurements.	8/14/97	8/15/97	**Completed**	Verified laboratory results; re-checked 30-day average calculations. Lab results passed QA/QC; details are published in Progress Report #1 delivered on 9/30/97.
2	Perform "walk down" of stream channel and adjacent areas between Pond A-4 and GS03 looking for any unusual conditions which might indicate new sources.	8/15/97	8/15/97	**Completed**	Observed no unusual conditions in Walnut Creek that would indicate a localized source area; several minor stream bank cuts and stream bottom fill locations were noted. Details are published in Progress Report #1 delivered on 9/30/97.
3	Confirm that water quality measurements at GS03 have returned to normal levels.	8/14/97	NA	Analytical Results received for the 10/3 and 10/5 sampling events.	Twelve carboys have been collected at GS03 and analyzed. Awaiting results for carboys which initiated sampling on 9/1, 9/4, 9/9/97 (baseflow sampling), 9/24, 9/27, 10/1, 10/8, 10/10 (baseflow sampling), and 10/27. Carboy for the period 10/3-10/5 had a Pu activity of -0.003 pCi/L. Carboy for period 10/5-10/8 had Pu activity of 0.008 pCi/L.

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	Project Activity	Sched. Start	Sched. Finish	Status	Comment
4	Re-analyze remaining sample aliquots for two of three elevated composite samples from GS03.	8/14/97	8/21/97	**Completed**	One result confirmed original measurement; other sample failed re-analysis.
5	Perform appropriate notifications to Site personnel and Stakeholders regarding elevated (May-June 1997) measurements at GS03.	8/15/97	8/15/97	**Completed**	Site and Stakeholders were notified. Notifications included both Occurrence Reporting and RFCA reporting contacts. Occurrence report filed 8/15/97. Regulators notified through RFFO on 8/15/97.
6	Perform sediment sampling in Walnut Creek upgradient drainages tributary to GS03	8/21/97	8/21/97	**Completed**	Collected 3 pond bottom samples from pond at Walnut and Indiana; and 16 samples from streambeds upgradient; preliminary results were submitted for validation on 9/17/97. Validated data were received on 9/23/97. These data were posted and sent out as a map attachment to Flash Brief #5 on 10/1/97. Data interpretation will be incorporated in Progress Report #2 to be published on 11/17/97.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
7	Perform additional sediment and soil sampling upgradient of GS03.	Approx. 9/1/97	Approx. 9/30/97	**Completed**	Additional samples will be collected if needed for further investigation of stream bed sediments. In September, soil samples were collected from eroded materials near the GS03 flumes. Two additional samples were collected at the GS03 flume pond on 9/9/97. Unvalidated results for this sampling event are 0.023 pCi/L Pu for the sample takes north of the flume and 0.071 pCi/L Pu for the sample taken south of the flume.
8a	Accelerate appropriate analyses to ensure timely data availability.	8/21/97	9/5/97	**Completed**	Accelerated sample turnaround to maximize data availability for decision making.
8b	Perform value engineering analysis to support acceleration of compliance monitoring.	9/6/97	9/30/97	**Completed**	Evaluated laboratory costs, turn-around times, and data quality. Collected and compared costs of accelerated analytical turnaround. Per K-H, all GS03 samples through end of FY97 will be expedited for two (2) week turn-around. Expected that turn-around will continue into FY98 for GS03.
9a	Perform laboratory services check.	8/21/97	9/15/97	**Completed**	QC samples are routinely collected according to RFCA technical design document (every 20th sample). This continues as designed. K-H has requested all POC's data be validated for FY98 sampling. Cost is not yet determined on expected turn-around.

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	Project Activity	Sched. Start	Sched. Finish	Status	Comment
9b	Submit additional sample duplicates, splits, rinseates, and blinds	9/15/97	11/15/97	Ongoing	The need for additional QC sampling is under evaluation.
10a	Compile all existing water, soil, and sediment radio-analytical results for GS03, GS10, and SW093 and associated upgradient locations.	8/21/97	9/15/97 for GS03 11/17/97 for GS10 12/31/97 for SW093	**Completed for GS03**	Evaluations for GS03 were presented in Progress Report #1 delivered on 9/30/97. Historical analytical data are being prepared for GS10 and SW093 evaluations.
10b	Interpret all existing water, soil, and sediment radio-analytical results for GS03, GS10, and SW093 associated upgradient locations.	9/15/97	9/30/97 for GS03 11/17/97 for GS10 12/31/97 for SW093	**Completed for GS03**	Detailed summary and analysis were published in Progress Report # 1 delivered on 9/30/97. Updates will be presented in Progress Report #2 on 11/17/97. Interpretation of data for GS10 and SW093 awaiting data compilation.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
11	Perform loading and fate and transport analyses. Evaluate statistical correlations using water-quality, flow, and precipitation.	8/21/97	9/30/97 for GS03 11/17/97 for GS10 12/31/97 for SW093	**Completed for GS03**	Evaluation is ongoing to aid in the definition of near-term activities; results and hypotheses will be made available as they are developed. Hydrologic, precipitation, and WQ results are evaluated for trends and correlations. Careful consideration was given to the difference in results and hypotheses; interim results and evaluation were published in Progress Report #1 delivered on 9/30/97. Updates for GS03 will be presented in Progress Report #2 on 11/17/97.
12	Perform synoptic sampling event in Walnut Creek for the first 24-hours of the upcoming Pond A-4 discharge.	8/25/97	8/30/97	**Completed**	This event monitoring utilized seven (7) automated samplers to collect time-paced composite samples for the first day of Pond A-4 discharge (8/29 - 8/30/97), effectively sampling the same (initial) 'plug' of water as it moves through the Walnut Creek drainage. The samplers performed flawlessly with each composite sample receiving the targeted 75 grabs. Grab samples for TOC and DOC were also taken on the rising limb of the discharge as an indicator parameter to define potential correlations. Accelerated WQ results will be used to evaluate for water-quality trends. Flash Brief #5 (10/07/97) presented sediment sampling results that were not included in Progress Report #1. (Late receipt of validated data precluded inclusion in the Progress Report #1.) Data are currently being validated under direction of APO. Results and associated evaluation will be included in Progress Report #2 on 11/17/97.

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	Project Activity	Sched. Start	Sched. Finish	Status	Comment
13a	Install additional monitoring stations upstream of GS03.	8/25/97	9/15/97	**Completed** **2 of 3**	New gaging station locations selected and readiness approvals received for installation. Locations will collect continuous flow-paced samples to assess transport in No Name Gulch, McKay Ditch, and Walnut Creek. Ecological approvals completed 8/27/97; soil disturbance approvals completed. Gaging station GS33, on No Name Gulch at Walnut Creek, was installed 9/10/97. Gaging station GS35, on McKay Ditch at Walnut Creek, was installed 9/12/97. Startup and operation began on 9/15/97 for both locations. A flume is currently being procured for gaging station GS34, on Walnut Creek upstream of McKay Ditch. Installation will be scheduled when the flume is received. GS33 collected a composite sample for the period 10/28-10/29. On 10/29, the first GS33 carboy was submitted for analysis and a second carboy installed to continue sampling. GS35 collected 2 samples for the periods 10/27-10/29 and 10/29-10/30. The carboy currently collecting samples at GS35 started filling on 10/30.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
13b	Install additional monitoring stations upstream of GS03 if needed to provide increased resolution.	9/30/97	12/31/97	Ongoing	Information derived from the new gaging stations will be used to determine whether additional locations are needed.
13c	Install additional source location monitoring station upstream of GS10.	10/1/97	11/1/97	Ongoing	Two source location monitoring station installations are expected. Additionally, performance monitoring location, GS37 was installed in the Central Avenue Ditch at a location north of Building 443. This station automatically records flow and collects storm water runoff in the drainage basin for Building 123 which is undergoing D&D in FY98. Ecological evaluation and approval completed on October 13, 1997.
13d	Install additional source location monitoring station upstream of SW093.	10/1/97	11/1/97	Ongoing	Procurements have been initiated for equipment for three new monitoring stations.
14a	Examine impact of RFCA watershed improvements on downstream WQ.	9/30/97	12/31/97	Ongoing	Watershed improvements were performed in FY96 and FY97. WQ results are being compiled and analyzed to provide information on contaminant transport. Information will be published in Progress Report #3 on 12/31/97.

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	Project Activity	Sched. Start	Sched. Finish	Status	Comment
14b	Review historical release report(s) for possible correlation with RFCA monitoring results.	9/8/97	9/30/97 for GS03 11/17/97 for GS10 12/31/97 for SW093	**Completed for GS03**	Historical releases for the Walnut Creek drainage will be reviewed to determine whether past releases may have contributed to the elevated Pu and Am measurements. Results for GS03 were published in Progress Report #1 delivered on 9/30/97.
15	Evaluate all Site activities potentially impacting GS03 water quality.	8/21/97	9/30/97 for GS03 11/17/97 for GS10 12/31/97 for SW093	**Completed for GS03**	Results and evaluation were published in Progress Report #1 delivered on 9/30/97.
16	Perform additional walkdowns to assess No Name Gulch and McKay Bypass ditch sub-drainages and to identify origin of baseflow.	8/20/97	8/20/97	**Completed**	Drainages show indication of recent high flow rates (likely from large storm events in first weeks of Aug./97). Baseflow was confirmed exiting pond at GS03 with no inflow noted. No indication of current baseflow from seeps or springs; no unusual conditions which may visually indicate a localized source area. Details were published in Progress Report #1 delivered on 9/30/97.

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	Project Activity	Sched. Start	Sched. Finish	Status	Comment
17a	Identify data gaps and uncertainties in monitoring approach and protocols to improve monitoring program.	8/18/97	9/30/97	**Completed**	Initial evaluation of pacing and baseflow sample collection frequency and developed changes to sampling protocols that minimize chances of low-volume samples. Findings and protocol changes were published in Progress Report #1 delivered on 9/30/97.
17b	Continue to identify data gaps and uncertainties in monitoring approach and protocols to improve monitoring program.	9/30/97	12/31/97	Ongoing	Detailed evaluation of pacing and baseflow sample collection frequency and developed changes to sampling protocols that minimize chances of low-volume samples.
18a	Share recent developments and information with the K-H Team's Actinide Migration investigators and solicit additional source evaluation hypotheses.	8/29/97	9/15/97	**Completed**	RMRS completed data exchange and consultation with Dr. Bruce Honeyman (CSM) on August 29th. Meeting minutes were distributed on Sept. 3rd and recommendations incorporated into the Plan for Source Evaluation and Preliminary Actions for Walnut Water-Quality Results. Extra sediment was set aside (from that collected on 8/21/97) to allow for independent evaluation by Actinide Migration investigators.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
18b	Continue to share recent developments and information with the K-H Team's Actinide Migration investigators and refine source evaluation hypotheses.	10/27/97	4/15/98	**Ongoing**	The October meetings on Actinide Migration Studies was held October 27-28, 1997 to provide updates and other technical information on the Actinide Migration Study and the Walnut Creek source investigation. Solicited recommendations on additional study areas.
19	Evaluate ground water data for wells in the vicinity of GS03, GS10, and SW093.	8/21/97	9/30/97 for GS03 11/17/97 for GS10 12/31/97 for SW093	**Completed for GS03**	Preliminary trending of Site-boundary well near GS03 (Well # 41691) shows GW Pu levels diminishing from 1.5 pCi/L to < 0.05 pCi/L between 1992 and 1997. Three additional wells were installed using improved drilling methods and these wells have subsequently showed no elevated Pu or Am. Results and associated evaluation were included in Plan Report #1 delivered on 9/30/97.
20	Complete and provide draft of RFCA-required *Plan for Source Evaluation and Preliminary Mitigating Actions for Walnut Creek Water-Quality*	6/17/97	7/17/97	**Completed**	Delivered draft *Plan* to regulators 7/17/97; comments on *Plan* from regulators received 8/5/97 and 8/7/97. Response to comments sent to DOE 8/27/97 for transmittal to regulators. May-June 1997 water-quality results from GS03 were addressed in latest revision of *Plan*. *Plan* was amended to perform source evaluations for Walnut Creek basin above GS03 and GS10.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
	Results (“*Plan*”).				
21	Complete *Final Plan for Source Evaluation and Preliminary Mitigating Actions for Walnut Creek Water-Quality Results*	8/5/97	9/15/97	**Completed**	Provided draft for internal K-H Team on 9/10/97; transmitted to DOE 9/12/97; and transmitted to regulators on 9/15/97.
22a	Complete Progress Report #1 for the *Plan*	8/21/97	9/30/97	**Completed** **Delivered on 9/30/97**	Progress Report #1 included analysis and evaluation of historic reports and readily available information and environmental data for GS03 and preliminary analysis for GS10. Initial conclusions regarding source were formulated and incorporated in this report. Data received after 9/15/97 were not included in this report.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
22b	K-H Team personnel (Chris Dayton, Keith Motyl, with technical support from George Squibb) provided, in a roundtable fashion, an update/briefing to Stakeholders on recent developments in the Walnut Creek Source Evaluation on 10/ 16. Representatives of EPA, CDPHE, local cities, CAB, DOE, and K-H Team participated.	10/16/97	10/16/97	**Completed**	SUMMARY • Recent sediment data and synoptic sampling results (from that received recently from the laboratories but collected in August and not covered in the most recent Progress Report #1) were presented and discussed. The tone was cordial and rarely confrontational. • On balance, Stakeholders agreed that investigation had discounted several hypothetical causes and perhaps the best remaining candidate was diffuse legacy source(s) and that a distinct source was not indicated by the so work so far. • Bill Fraser of EPA closed the meeting by noting that the Stakeholder group believed RF was responsive and thorough in their source investigation and appeared to be doing everything possible to ID the source(s). • In closing Westminster complimented RF on the quality and understandability of Progress Report #1.
23	Complete Progress Report #2 for the *Plan*.	10/1/97	11/17/97	Pending	Progress Report #2 will include analysis and evaluation of existing GS10 and GS03 data and the newly acquired GS03 data and other necessary environmental information as determined by the Phase 1 activities. Report #2 will include a preliminary assessment of SW093. Conclusions regarding GS10 and GS03 sources will be refined after inclusion of the new data and incorporated in this report.

	Project Activity	Sched. Start	Sched. Finish	Status	Comment
24	Complete Progress Report #3 for the *Plan*.	11/18/97	12/31/97	Pending	Progress Report #3 will include analysis and evaluation of all GS10, GS03, and SW093 investigative information and environmental data. Conclusions will be finalized and incorporated in this report.
25	Complete Final Evaluation Report and Mitigating Action Plan addressing elevated Walnut Creek sources.	1/1/98	4/15/98	Pending	The Final Evaluation Report will include the results and conclusions of the source evaluation actions. The Mitigating Action Plan will evaluate options (cost, efficacy, etc.) and identify alternatives for effectively removing and/or reducing impacts of identified sources.

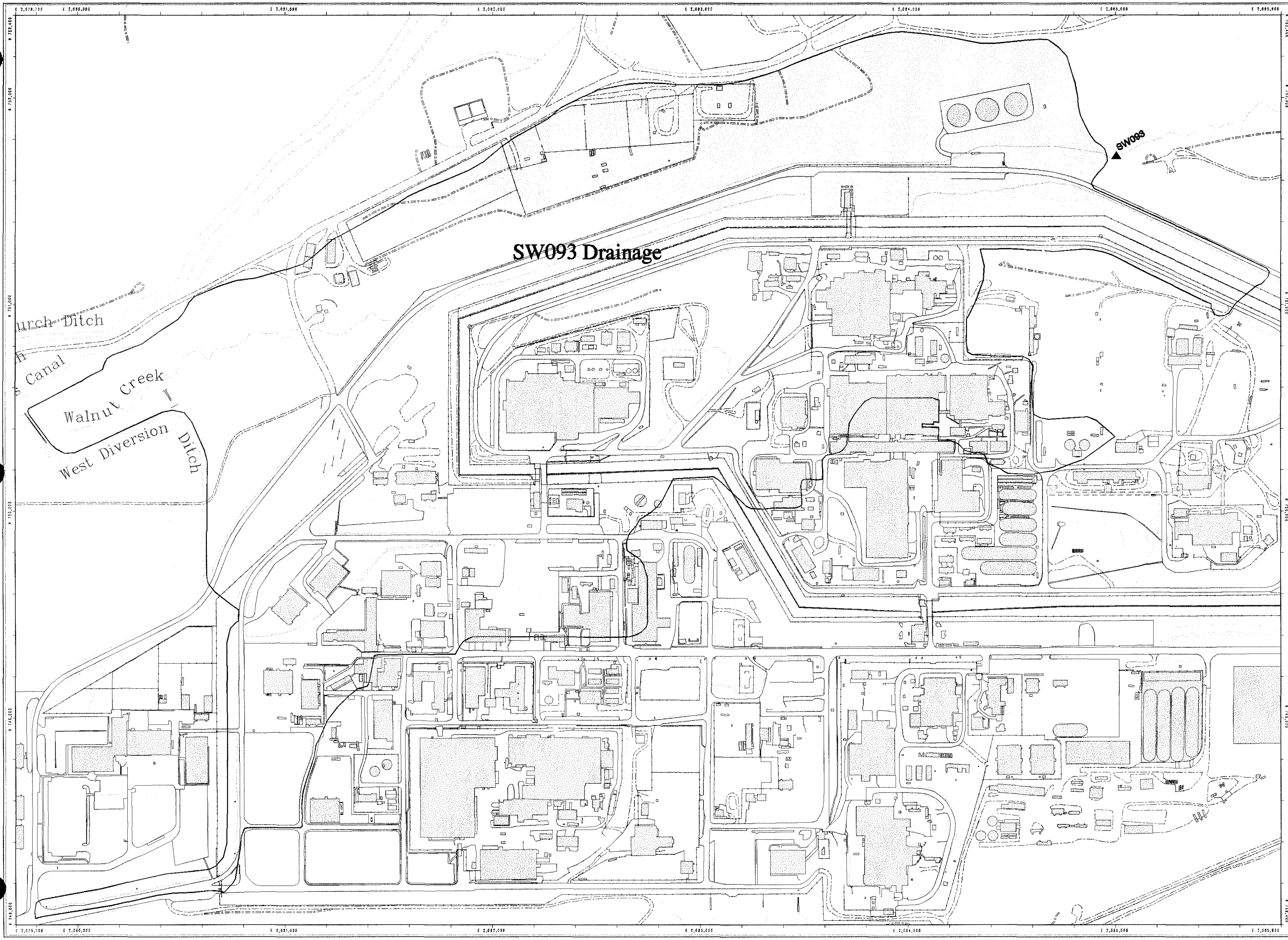

Figure 5-1
SW093 Drainage Area

Legend

Sampling Stations
- ▲ Point of Evaluation
- Performance Location

Drainage
- SW093 Drainage

Standard Map Features
- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95

Scale = 1 : 5670
1 inch represents approximately 473 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
Rocky Mountain Remediation Services, L.L.C.
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P.O. Box 464
Golden, CO 80402-0464

MAP ID: 98-00020-Map11 November 13, 1997

/gis2/projects/fy98/98-0020/map11/sw093-drng.aml

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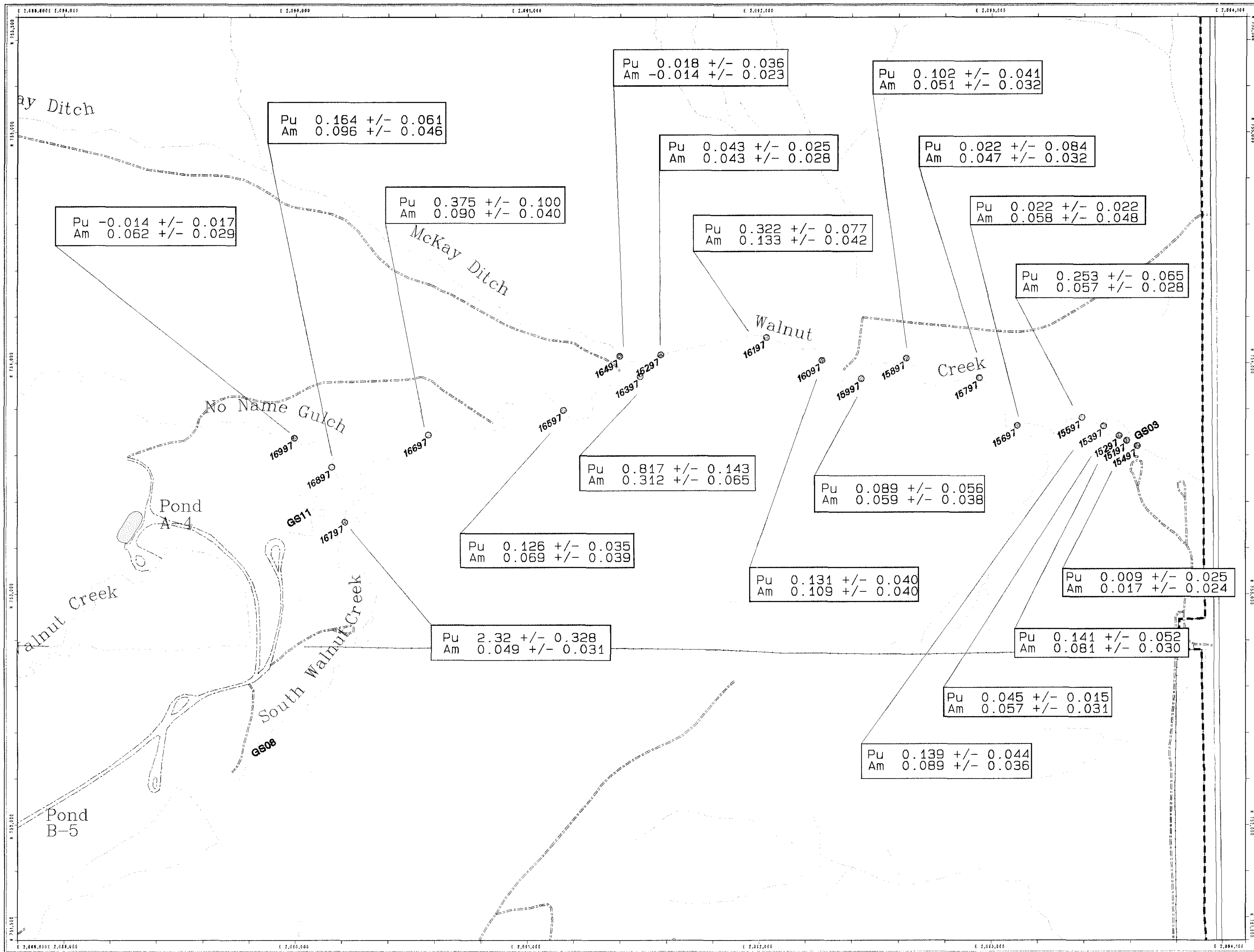

Figure 3-18
Sediment Sampling Locations in Walnut Creek
August 21, 1997

Legend

Gaging & Sampling

- △ Gaging Station (Point of Compliance)
- Sediment Sampling Location (Location Code Shown, Aug. 21, 1997)

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 5530
1 inch represents approximately 461 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
Rocky Mountain Remediation Services, L.L.C.
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MAP ID: 98-0020-Map3

November 13, 1997

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44

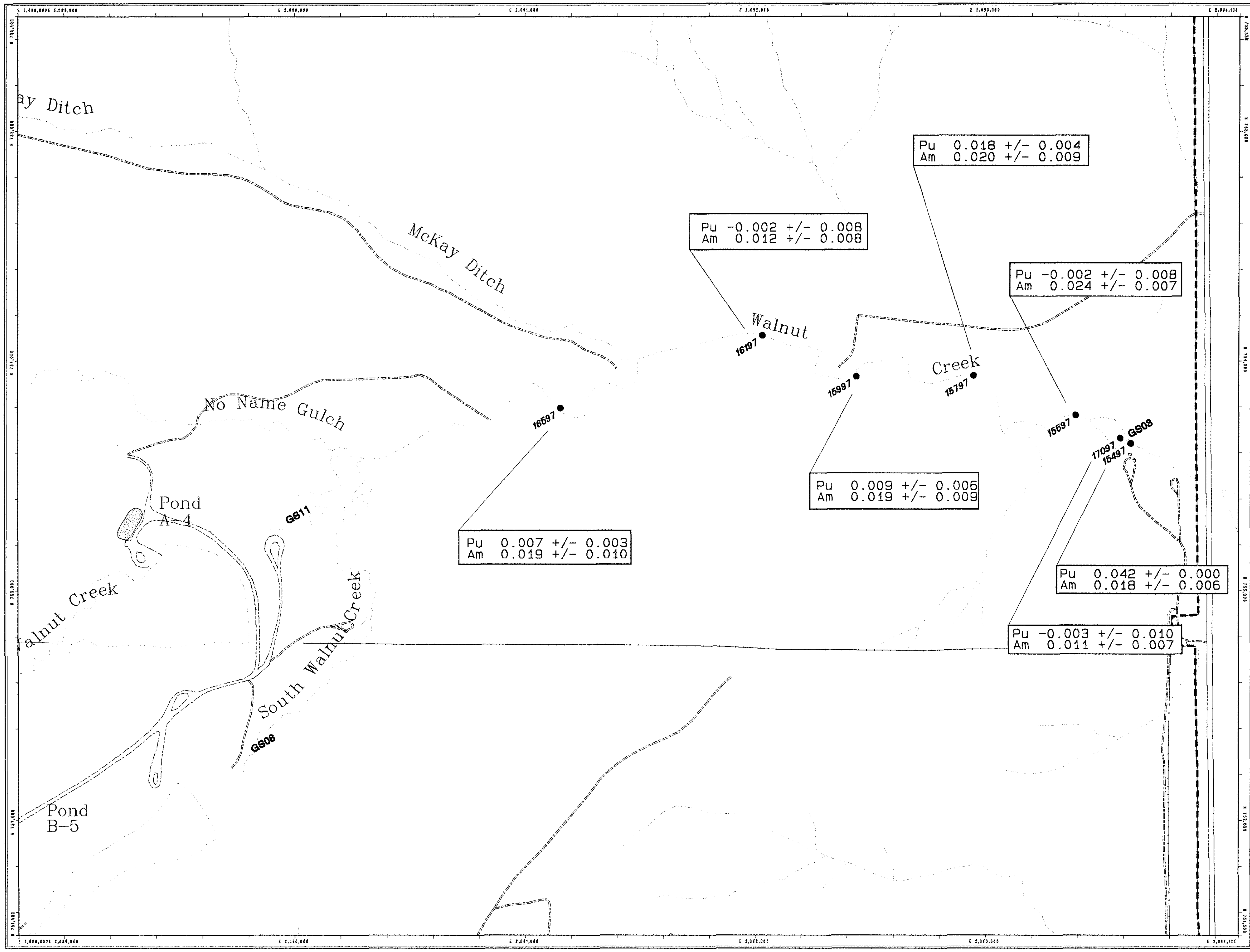

Figure 3-15

Surface-Water Sampling Locations for Walnut Creek Synoptic Sampling Event
August 29-30, 1997

Pu & Am (pCi/L)
Un-validated Results

Legend

Gaging & Sampling

- Gaging Station (Point of Compliance)
- Synoptic Sampling Location (Aug. 29 - Aug. 30, 1997)

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95

Scale = 1 : 5530
1 inch represents approximately 461 feet

100 0 200 400 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Prepared by:
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MAP ID: 98-0020-Map2 November 18, 1997

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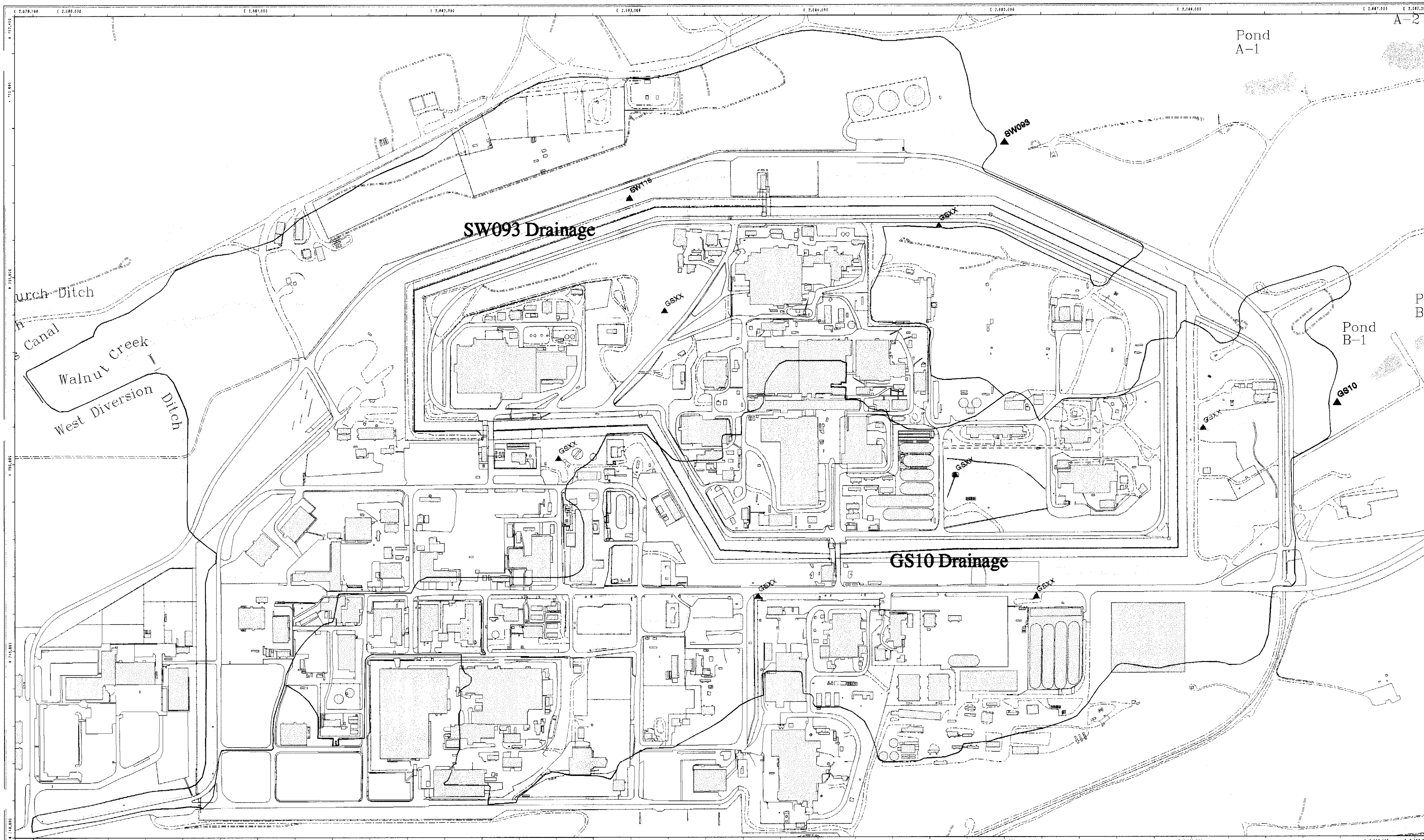
Figure 9-1

Proposed Source Location Monitoring Stations for GS10 & SW093 Drainage Areas



Legend

Sampling Stations

- ▲ Point of Evaluation
- ▲ Proposed Source Location Monitoring Station

Drainage

- SW093 Drainage
- GS10 Drainage

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95

Scale = 1 : 5580
1 inch represents 465 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 98-00020-Map12 November 18, 1997

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125

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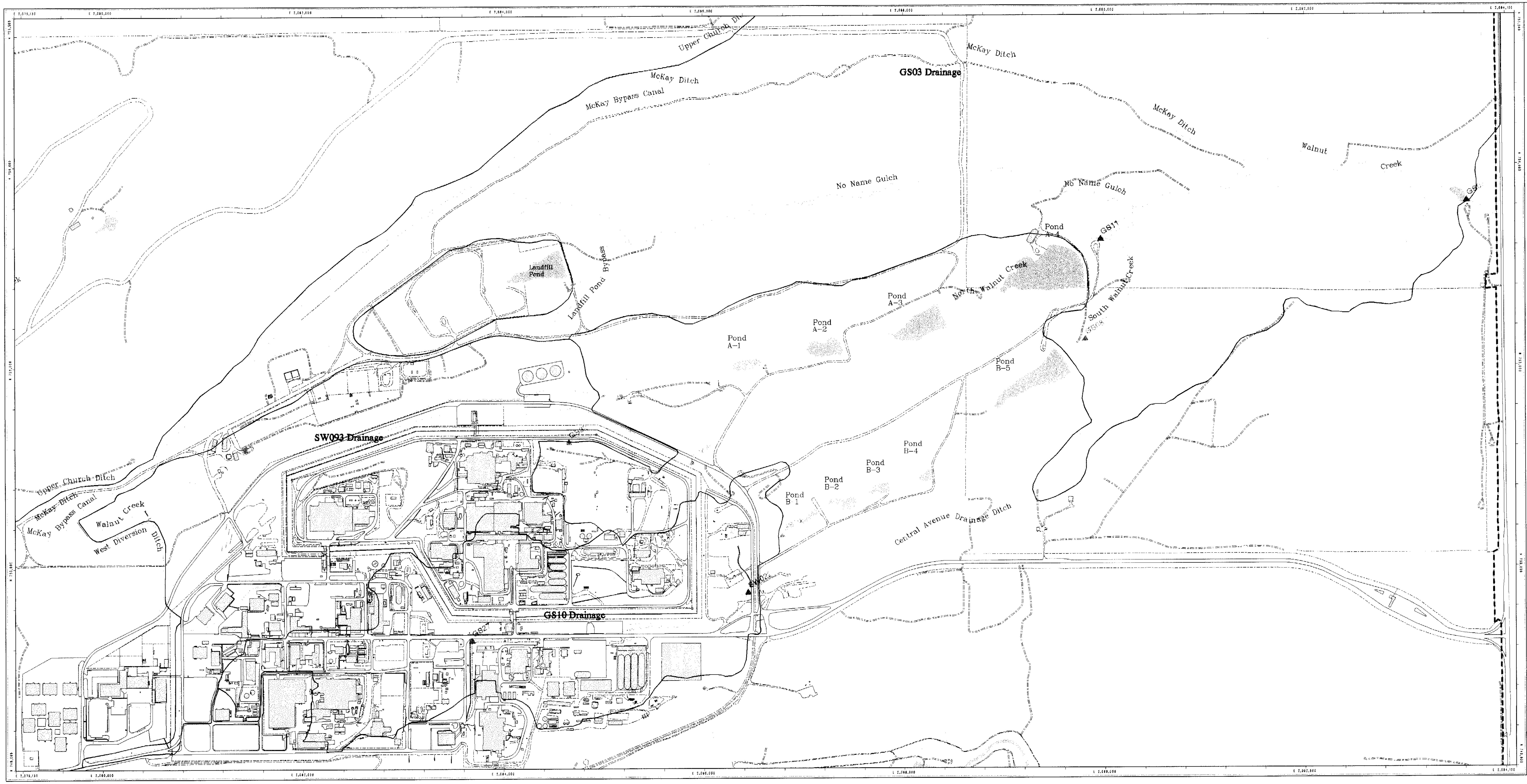

Figure 2-3
Selected Surface-Water Monitoring Locations in Walnut Creek

Legend

Gaging & Sampling

▲ Surface Water Monitoring Location

Drainages

- GS03 Drainage
- SW093 Drainage
- GS10 Drainage

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 9700
1 inch represents approximately 808 feet

250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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16

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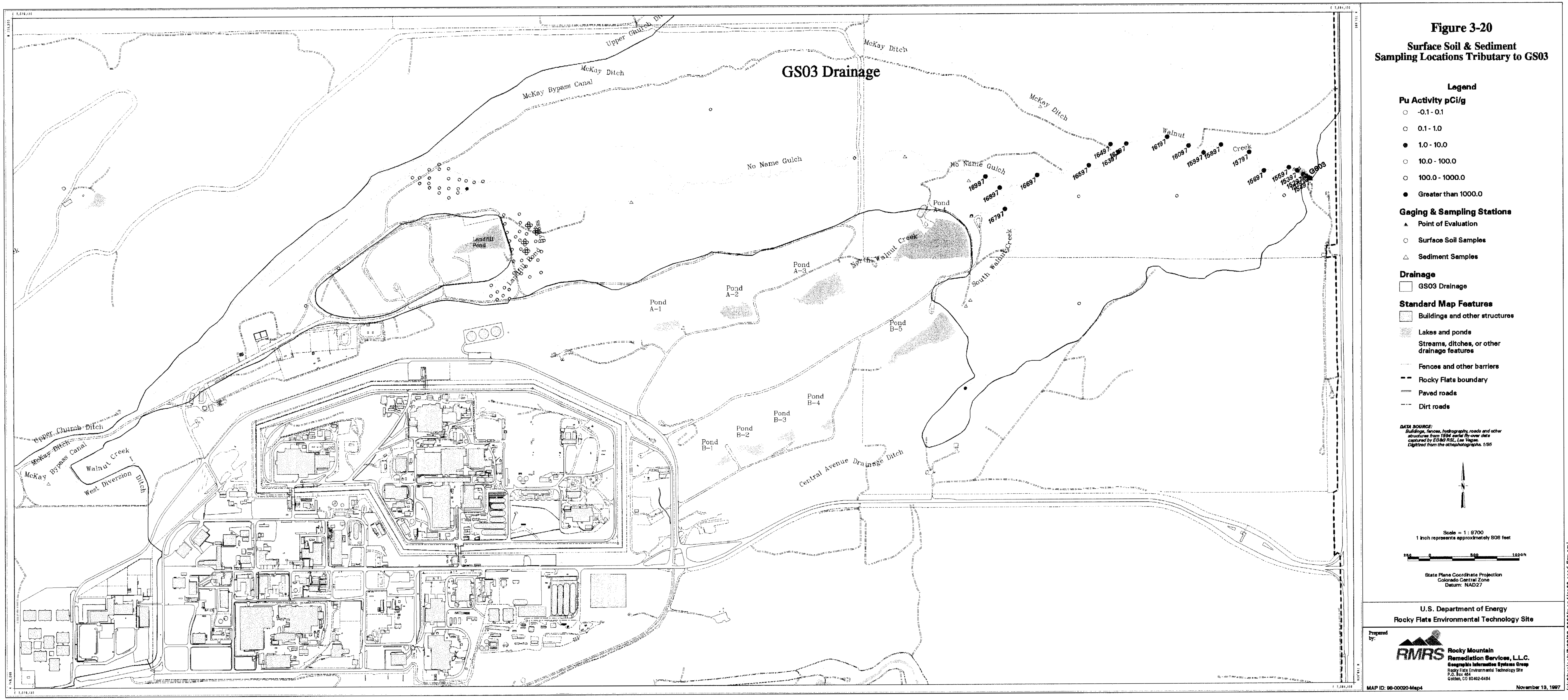

Figure 3-20
Surface Soil & Sediment Sampling Locations Tributary to GS03

47

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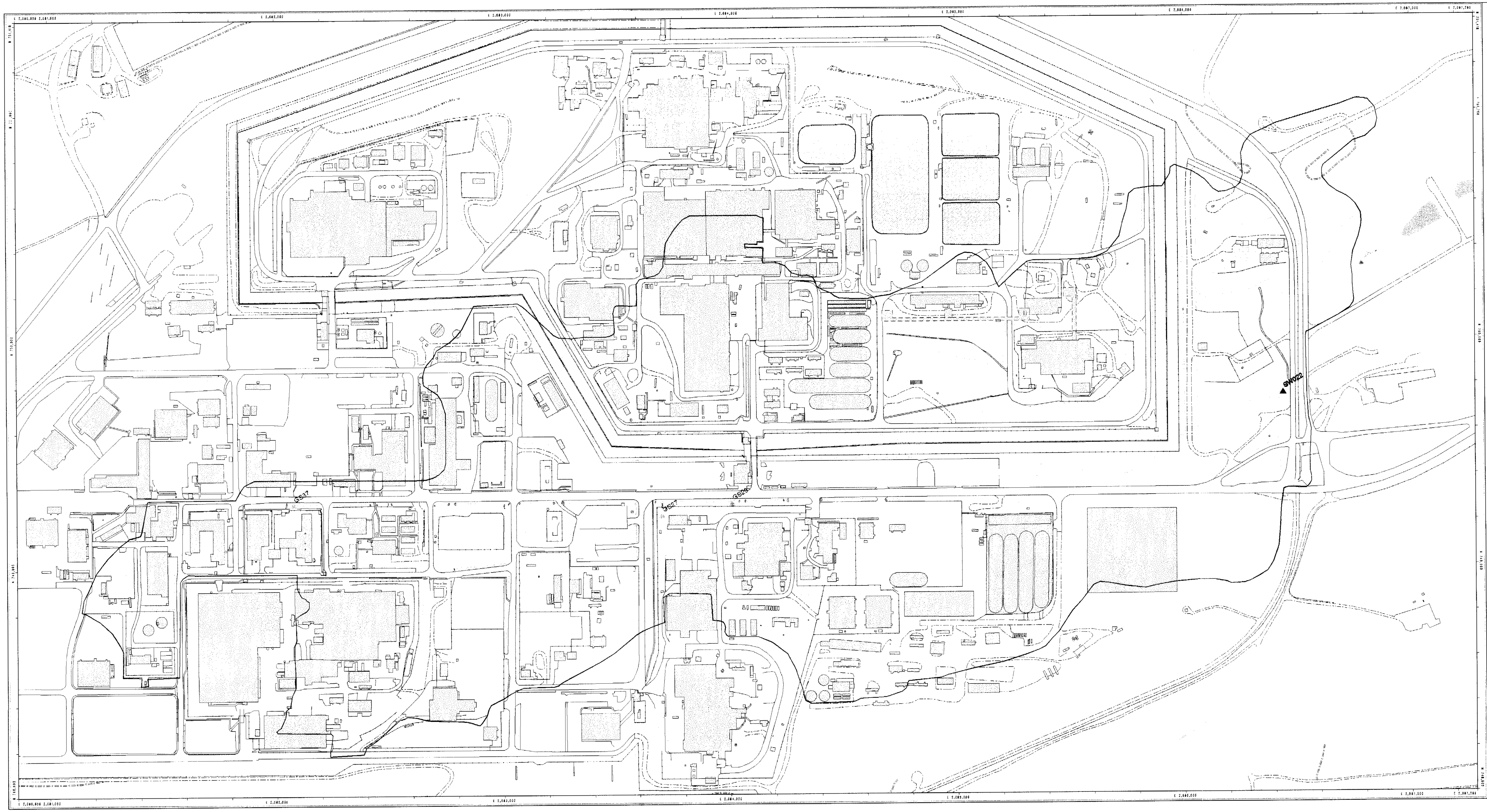

Figure 4-1

Selected Surface Water Monitoring Locations Tributary to GS10

EXPLANATION

Drainage

GS10 Drainage

Gaging & Sampling Stations

Point of Evaluation

Performance Monitoring

New Source Detection

Standard Map Features

Buildings and other structures

Solar evaporation ponds

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Contour (20-Foot)

Paved roads

Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the othophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 (?) meter resolution.
The DEM post-processing perfromed by MK, Winter 1997.

Scale = 1 : 4230
1 inch represents approximately 353 feet

100 0 200 400 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 98-0020-Map5

November 19, 1997

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50

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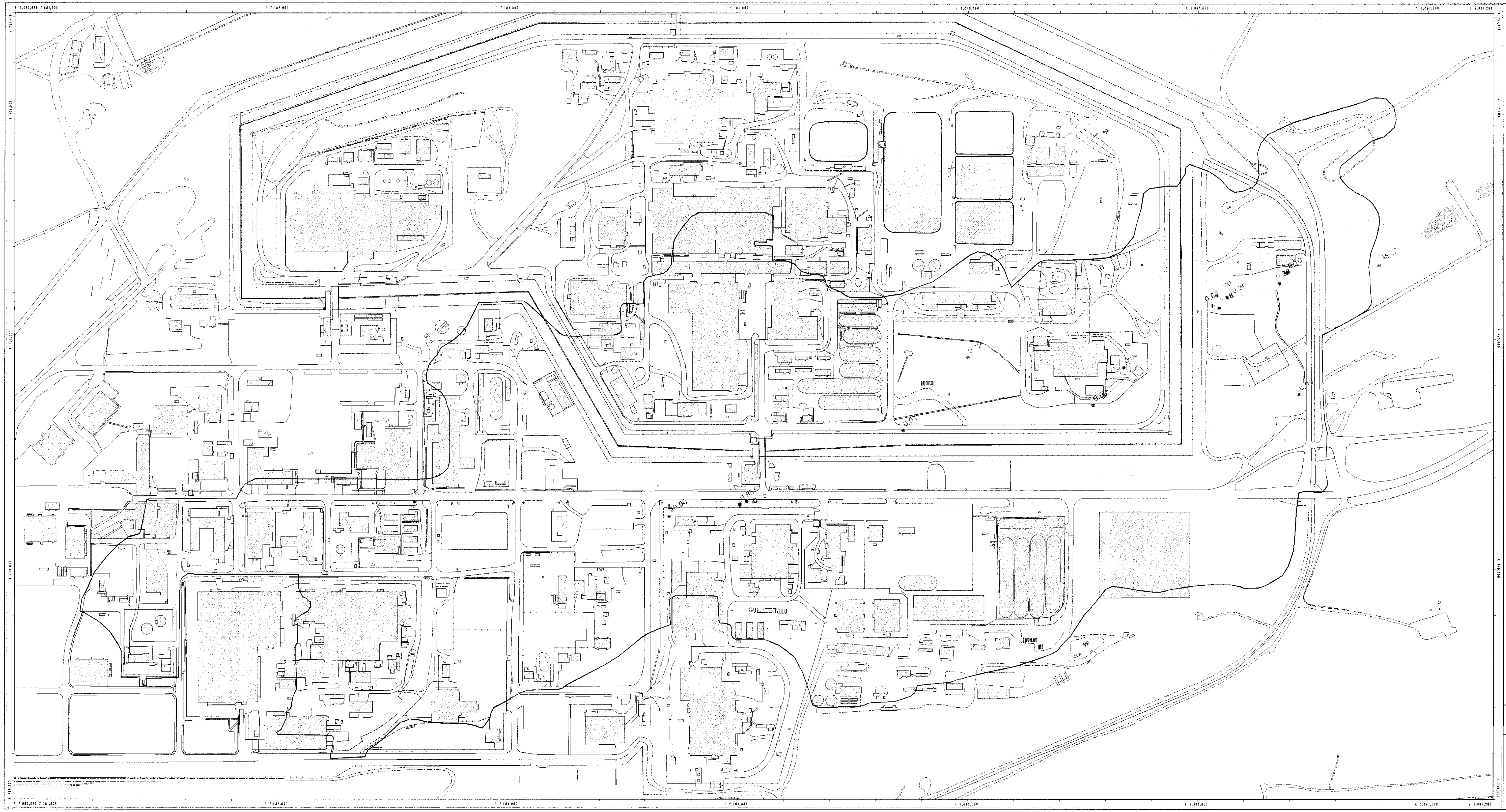

Figure 4-32

Surface Water Sampling Locations Tributary to GS10

Maximum Pu (pCi/L)

EXPLANATION

Drainage

GS10 Drainage

Gaging & Sampling Stations

Point of Evaluation

Selected Surface Water Sampling Locations

Standard Map Features

Buildings and other structures

Solar evaporation ponds

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Contour (20-Foot)

Paved roads

Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 (?) meter resolution. The DEM post-processing perfromed by MK, Winter 1997.

Scale = 1 : 4230
1 inch represents approximately 353 feet

100 0 200 400 Ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 98-0020-Map6

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77

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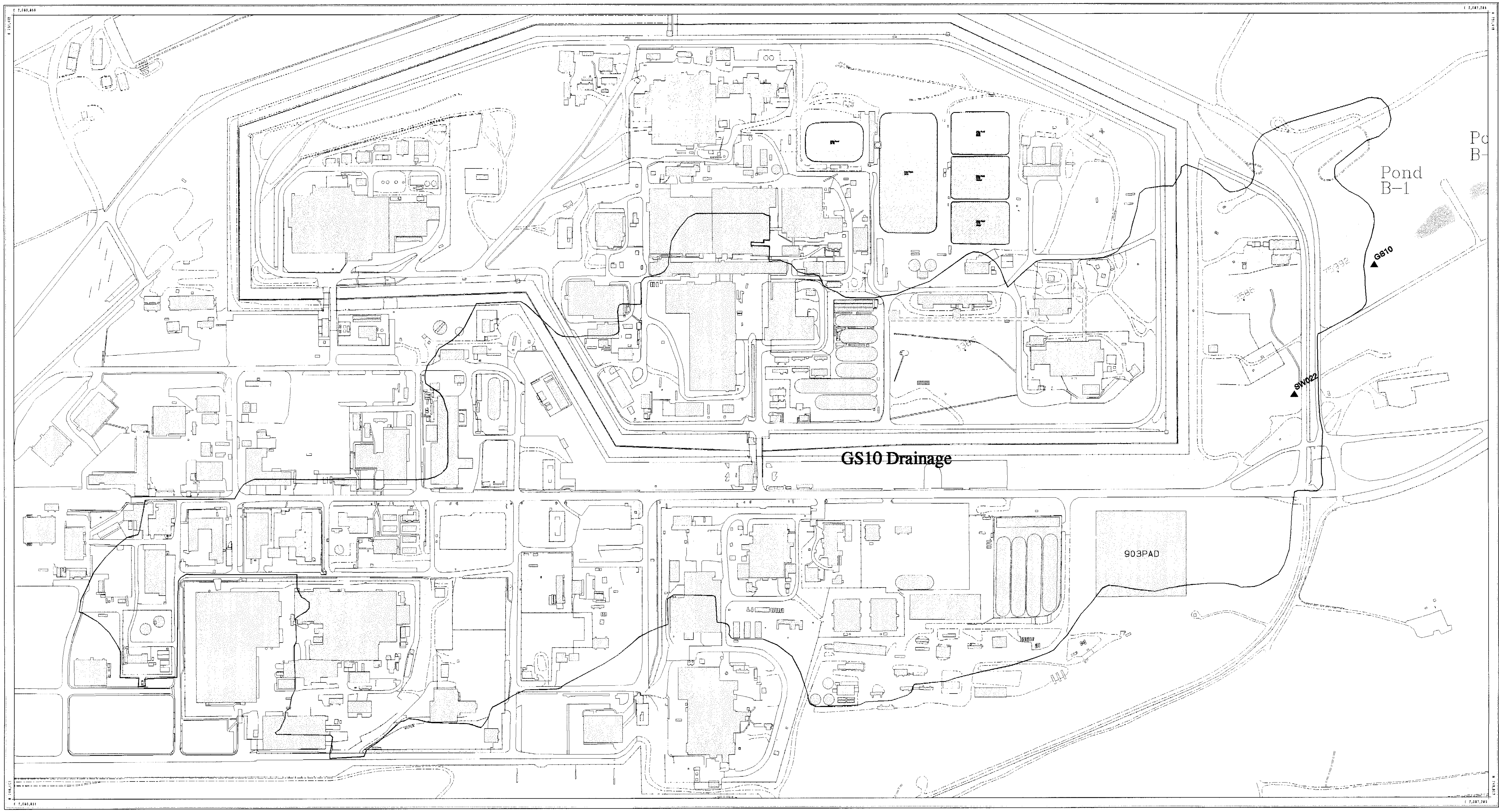

Figure 4-37

Groundwater Monitoring Well in GS10 Drainage

Legend

- ▲ Surface Water Monitoring Location
- Groundwater Well (Currently sampled for PU & Am)
- Groundwater Well (With historical record of total PU & Am > = 0.15pCi/L)

Drainage

- SW093 Drainage

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95

Scale = 1 : 4230
1 inch represents approximately 353 feet

100 0 200 400 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 98-00020-Map8 November 17, 1997

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99

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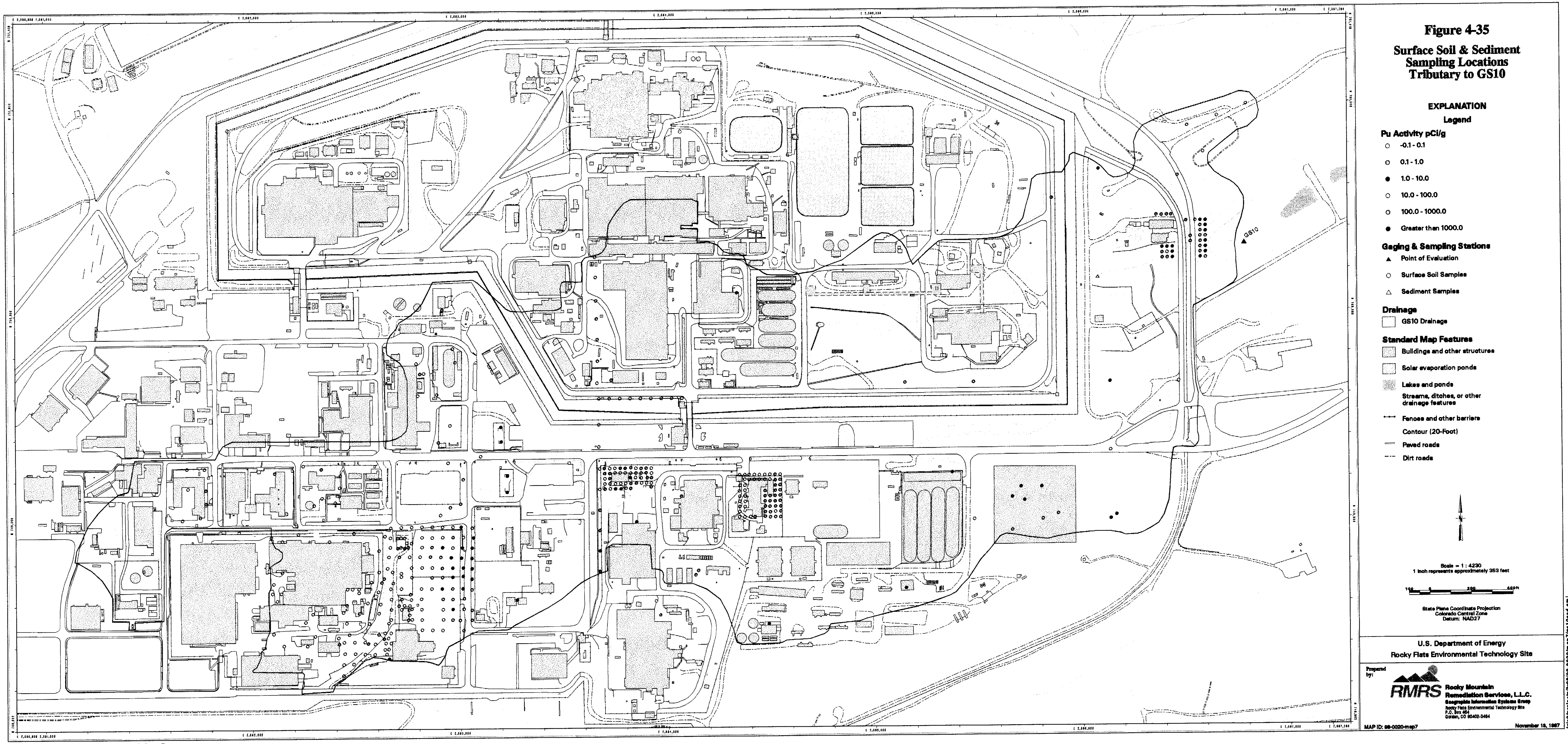

89

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Figure 4-33

Gamma Spectioscopy Data in GS10 Drainage Pu-239 nCi/g

EXPLANATION

HPGe Data Ranges--

- 0.0 - 0.1
- 0.1 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- 1000 - 10000

Drainage

- GS10 Drainage

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

NOTE:
Raw field data which has not been evaluated and may be influenced by building shine.

The HPGe field of view (FOV) or radius of influence, assumes a homogeneous surface distribution. The FOV represents a circle where 90% of the flux originates. The radius, for each HPGe sampling location, is based on the height of the detector above the ground.

DATA SOURCE:
HPGe data from Ron Reimen, Gamma Survey Group, Safeguard Measurements, EG&G Rocky Flats, Inc. June 1994
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95

Scale = 1 : 4230
1 inch represents approximately 353 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 98-00020-Map9

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86

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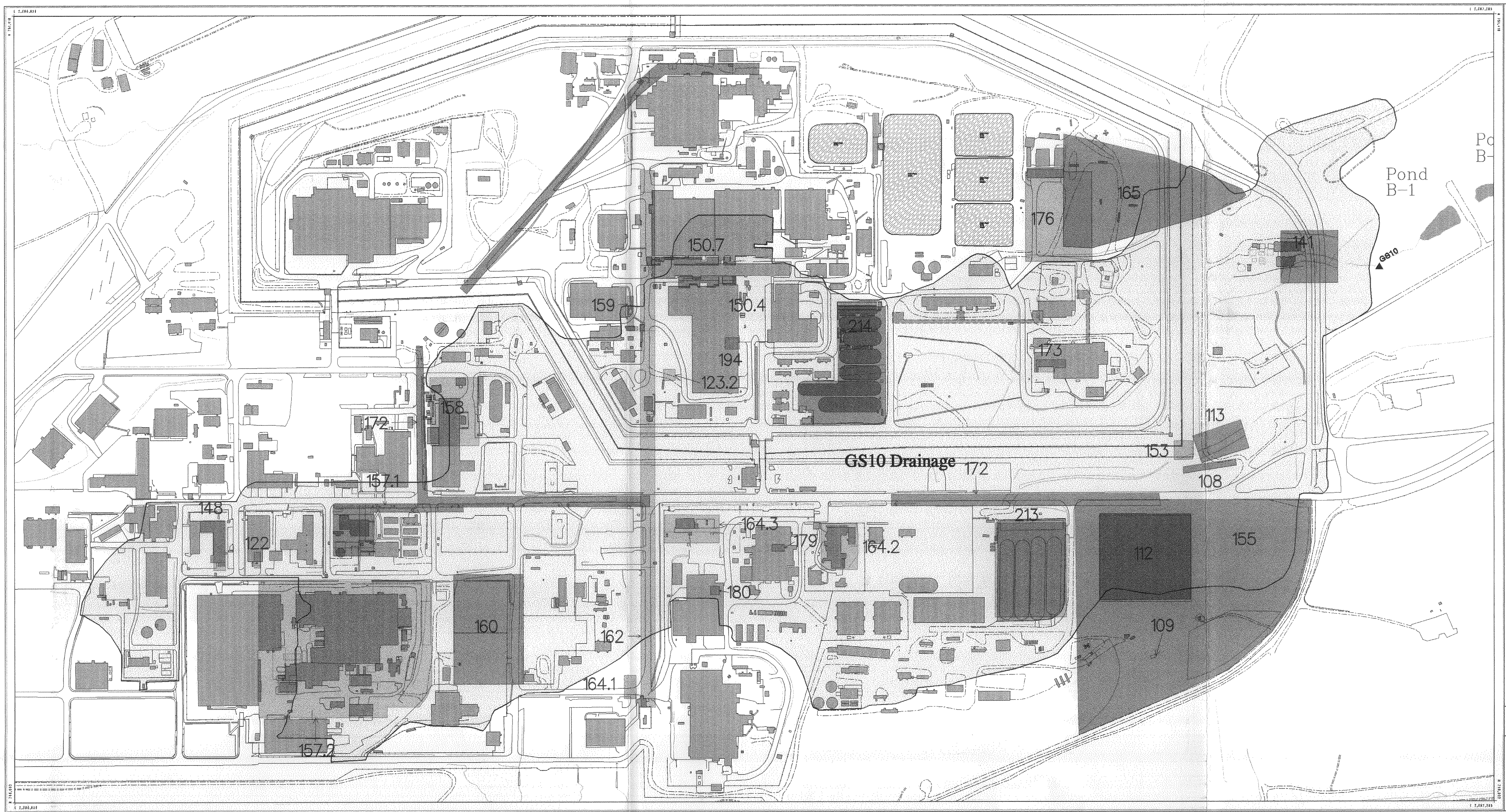

Figure 4-36

IHSSs Tributary to the GS10

Legend

- Plutonium IHSS Locations
- General Radionuclide (RAD) IHSS locations

Drainage

- SW093 Drainage

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95

Scale = 1 : 4230
1 inch represents approximately 353 feet

100 0 200 400 Ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 98-00020-Map10

November 17, 1997

/gis2/projects/fy98/98-0020/map10/gs10-ihss.aml

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